We, the Port Hardy Ferrochromium Review Panel, duly appointed by the Minister of Environment for the Province of British Columbia, the Minister of Environment for Canada, and the Minister responsible for Western Economic Diversification Canada, have prepared the "Report of the Port Hardy Ferrochromium Review Panel", fully endorse its conclusions and recommendations, and submit these for the consideration of the honourable ministers, in accordance with our terms of reference.

Dated at the City of Vancouver, Province of British Columbia,
this 28 day of January, 1991.

Mr. Bryan Williams, Chairman

Mr. George Davies, Member

Dr. Paul West, Member

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
G. E. DAVIES

ACKNOWLEDGEMENTS

The Panel gratefully acknowledges all participants in this review process, including the many public groups and individuals. We have endeavoured to provide them with a fair, thorough and open process.

Sherwood Metallurgical is acknowledged for its cooperation with this review.

In this very technical examination of the proposed project, the Panel was assisted considerably by expert advice from its consultants, which are identified in the text. As well, those consultants retained on behalf of the intervenor groups are also thanked for their valued contributions.

The Panel has appreciated the helpful cooperation of a number of government departments, ministries, and agencies, which are identified in the text. We would especially acknowledge the B.C. Ministry of Environment and the Federal Environmental Assessment and Review Office which sponsored this review.

Transcripts were provided by **PRS: Professional Reporting Service Ltd.** of Victoria. These were prepared in a timely and professional manner.

Our Panel was considerably assisted by our counsel, **Mr. Murray Rankin**, who ensured that our procedures were fair. He effectively led evidence and questioned witnesses. We acknowledge the cooperation of counsels for the intervenors and the proponent who worked in a cooperative spirit with Mr. Rankin to ensure that our procedures were acceptable to all parties.

Finally, we owe our special gratitude to the comprehensive, thorough, and professional services of our panel's secretariat, principally **Mr. Ken Youds**, assisted by **Mrs. Irene Stewart**. We relied heavily on Mr. Youds' steadfast support. The secretariat organized and managed the review process including organizing and managing our hearings, liaising with government, media, the proponent, and the public, managing all records and distributing them in timely fashion to numerous groups and libraries, handling most correspondence, and coordinating the editing and production of this report.

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GENERAL CAVEAT

We, the Port Hardy Ferrochromium Review Panel, have endeavoured to our best ability, with the time and resources available, to produce a competent, thorough and well reasoned report that will be of practical value to government, to the proponent and to the public. We feel that the conclusions and recommendations reached are soundly based.

We wish to advise readers that, due to the finite time available to us, there could be some aspects, issues or considerations which might be judged to be too lightly treated in the report. Also, due to the large number of scientific calculations and numerical expressions contained in this report, it is possible that some typographical or arithmetic errors may have escaped our proofreading. If so, we apologize and request the readers' indulgence.

SUMMARY

This review has been initiated and jointly sponsored by the federal and British Columbia governments. The Panel, appointed under the B.C. Environment Management Act, was instructed to conduct a thorough and open public review of the environmental and social implications of the proposal by Sherwood Metallurgical to construct and operate a ferrochromium smelter near Port Hardy, British Columbia.

This review has been conducted, in accordance with the terms of reference, in a manner consistent with the federal Environmental Assessment and Review Process guidelines. There has been full public access to information, procedures fair to all parties were adopted and followed, and extensive public hearings were held.

The Port Hardy Ferrochromium Review Panel respectfully submits this report to the federal Minister of Environment, the federal Minister responsible for the Western Economic Diversification Canada, and the British Columbia Minister of Environment.

The purpose of the SUMMARY is to provide an overview of our general conclusions and our recommendations regarding this project. It does not include the background information and analyses that are essential to understanding these conclusions and recommendations. It is sincerely hoped that the full text will be studied thoroughly.

The Panel has examined thousands of pages of scientific and expert evidence as well as thousands of pages of transcript, and it has considered the hundreds of written and oral views of the public that have been expressed on this issue. The following general conclusions are derived from the consideration and analysis of this overwhelming accumulation of information. The recommendations listed here are extracted directly from the full text in the order they are presented.

General Conclusions

From our mandate, which was to consider the technology, the environmental issues and the social issues, and in consideration of all the evidence before us, we have drawn the following three general conclusions:

(1) **Technology:**
The technology of the proposed plant is feasible, although refinements and clarifications will be necessary, as set forth in our report, in order to achieve a satisfactory final design;

(2) **Environment:**
Provided the comprehensive and stringent conditions set forth in our report are applied to the design, construction, operation and monitoring of the Sherwood plant, its environmental impacts are expected to be manageable and acceptably low, however the selected site near Bear Cove is not ideally suited due to the general environmental sensitivity of Hardy Bay; and

(3) **Social Issues**:

a) General
Provided the environmental impacts are managed in accordance with the recommendations of this report, the Sherwood plant would yield a net social benefit to Port Hardy, based upon its local economic value.

b) Native
The Bear Cove site is not acceptable in light of native issues which must be resolved by litigation or settlement.

In light of the foregoing, the proponent and government may choose to seek an alternative location, possibly in the Port Hardy vicinity, that is suitable to all parties.

RECOMMENDATIONS

Process Technology

1. The Panel recommends that, in view of the controversy surrounding the solubility of chromite ore, samples of all chromite ores should be subjected to leach testing before shipment to the plant.

2. The Panel recommends that the proponent be required to build and operate a dedicated docking and off-loading facility from the commencement of the project, in order to assure effective control of the raw materials.

3. The Panel recommends that a reliable, acceptable scheme for off-loading must be designed that sufficiently minimizes spillage to meet stringent sediment guidelines. This will require considerably more engineering effort.

4. It is recommended that, from the dock to the storage area, the conveyor system must be covered and there must be dust extraction hoods and water spray at transfer points in accordance with accepted engineering practice.

5. It is recommended that, before proceeding with construction, the final raw material handling and storage scheme be approved by the appropriate ministries of government, with the objective that it must satisfy those bodies that the opportunities for spillage and other losses of material to the environment are minimized.

6. It is recommended that the raw materials storage facility should be a fully enclosed building in order to prevent wind losses and any potential leaching from the storage site.

7. It is recommended that the system for recycling the baghouse dust must be totally enclosed and that the technology for recycling baghouse dust (potentially contaminated with arsenic, zinc and chromium) must eliminate fugitive dust emission, based on Best Available Control Technology in current use.

8. The Panel recommends that, due to the untested nature of this plant and the remaining uncertainties, it is appropriate to apply a "worst case scenario" approach to its environmental assessment and any permits that might be issued for this project.

9. The Panel recommends that emissions from the flare stack must be included in the permit levels for total emissions, expressed in grams per hour, from this plant. These combined emissions should not exceed the permitted total mass rate.

10. It is recommended that any water used to remove "scale" from the steam ejector should be handled as contaminated process water.

11. The Panel recommends that the data on which the water treatment plant is designed, including the design criteria, equipment selection and sizing, be fully resubmitted by the Proponent and reviewed and approved by the B.C. Ministry of Environment. This review must take into account:

    (1) adequate rainwater and process water storage for flood conditions.

    (2) plant sizing to treat surplus water in times of excessive rainfall.

    (3) contingency plans in the event storage and plant capacity are inadequate for short term emergencies.

12. The Panel recommends that containment basins should be of sufficient volume to store all excess process water and excess storm water run-off, with provision of additional storage capacity, such as a lagoon, to handle heavy rainfall periods. The plant must be zero discharge as proposed.

Receiving Environment

1. The Panel recommends that in the public interest, hazardous substances such as chromium should be regulated so that no detectable effect on human health is created. This includes ensuring that the risk of additional cancer incidence is minimized to less than one in a million in accordance with standards adopted by a number of organizations internationally, including the U.S. EPA.

2. Accordingly, it is recommended that the ambient objective for Chromium VI should be the current EPA ambient level suggested by the proponent, an air concentration of 0.085 ng m^{-3}.*

3. The Panel recommends that, wherever the plant is sited, the total chromium ambient value of 0.002 ug/m^3, based on the recent EPA RfC proposal, must be achieved, met or exceeded in air modelling analysis for all inhabited areas.

4. Also, it is recommended that the current B.C. total chromium ambient standard of 0.05 ug/Nm^3, enforced on a yearly basis, not be exceeded at any point outside the perimeter of the plant.

5. It is recommended that the emission rate for total chromium be set at 2.0 mg Nm^{-3} (refer to Lemmon: file 393) and allowed only if the ambient levels set above are predicted to be achievable by the modelling studies. The corresponding mass rate is 41.7 g/h (grams per hour).

6. Furthermore, it is recommended that the 0.05 ug/Nm^3 total chromium value should be regulated as achievable on an annual basis, and not the implied 24 hour in the B.C. Pollution Control Objectives. (file 405-Govt.41).

7. It is recommended that all ambient values should be regulated by specified time periods (hourly, 24 hour or yearly) in the B.C. Pollution Control Objectives.

8. The Panel recommends that the proponent be required to complete further BACT analysis of air emissions, based on and including the items suggested in the correspondence from panel experts as contained in files 566-Pan/Ex.47 and 461-Panel.50.

9. It is further recommended that the Ministry of Environment should await the proponent's completion of this BACT analysis prior to the consideration of the issuance of permits.

10. Based on its experience in this review, the Panel recommends that future Environmental Review Panels and other major project review processes have available the emission values

(mass concentration and mass rate) that have been set in waste management permits over the five-year period prior to the particular assessment.

11. Furthermore, the Panel recommends that standard conditions (percentage O_2, CO_2 in the gas stream, temperature, pressure) be clearly stated for all emission sources, including power boilers and combined process-power-fugitive emission stacks.

12. The Panel recommends that, for permitting purposes, the proponent should provide estimates in kg/hr. of fugitive particulate emissions from all sources.

13. The Panel recommends that the permit values in Table 3-A2 for SO_2, nitrous oxides (as NO_2) and particulate be adopted.

14. It is recommended that the proponent complete its air modelling on the basis of a 34 meter stack height, in accordance with the GEP guideline for maximum stack height to building height ratio of 2.5. Dilution air should not be used.

15. The Panel recommends that any permit issued should specify that organic compounds (specifically PAH) should not occur at any detectable level in the stack gases.

16. The Panel recommends that with regard to emissions for chromium and trace elements a conservative approach should be adopted by setting the revised values given in Table 3-B1 (Section 3.3.2) as permit levels.

17. The Panel recommends that the proponent undertake a complete revision and summary of the deposition data.

18. It is recommended that the monitoring program should include observation of the effects that biocide treatments have on marine life.

19. It is recommended that the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment should require the proponent to obtain approval in advance of any alterations to the operation and cleaning of the seawater discharge pipe.

20. The Panel recommends that the intent of the British Columbia regulations, with respect to thermal effects of marine discharges, should be followed in regard to any permits issued for the Sherwood plant.

21. The Panel recommends the development and publication of guidelines for thermal discharges to marine and freshwater bodies in British Columbia.

22. It is further recommended that the temperature at the outlet and the temperatures at successive radii (20, 50, 100 meters) be measured during the start-up period under a variety of current conditions to verify the engineering estimates.

23. It is recommended that the full and satisfactory description of the marine baseline research program must be a condition for this project to proceed.

24. It is further recommended that the baseline research requirements be specified by the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment.

25. It is recommended that any approval of the environmental acceptability of the Sherwood's water treatment proposal must be made on the basis of clarification of:

    (1) Storage capacity for unusual events rapid, heavy rainfall at night or during plant shutdown conditions. The proposal to sample and then discharge storm water is not considered to afford adequate environmental protection.

    (2) Discharge method and location.

26. The Panel recommends that the most appropriate criteria for pollutant discharge for application to the Sherwood plant are those given in Table 3-C.

27. Furthermore, the Panel recommends that:

    (1) These criteria should <u>not</u> be subject to variance during periods of excess runoff as proposed in the 1979 Objectives.

(2) Bioassay must meet 96-h LC (lethal concentration) at 100 percent survival for 100 percent strength waste water, both on a static and flow-through basis using salmonids.

(3) Daphnia Magna acute lethality toxicity testing must be applied.

(4) The total suspended solids (TSS) must be subject to meeting the total chromium requirements (i.e. at 10 mg L^{-1}, the percentage of chromium in the TSS should be such that the total chromium value of 0.05 mg L^{-1} is achieved).

(5) Compliance must be achieved by process (blowdown) and storm water separately. Dilution of one by the other is not to be permitted.

28. The Panel recommends that, as a condition of constructing the plant at this site, a shoreline buffer zone sufficient to protect the current abundance of foreshore habitats and species, should be part of the prescribed development plan.

29. The Panel recommends that the construction and development plan for the site should be guided by the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment, with attention to minimizing impacts to either of the two unnamed streams which cross the site and drain onto the foreshore, and to avoiding soil-laden runoff and slippage directly onto the foreshore.

30. Based on the evidence considered and the objective of avoiding significant environmental impact, the Panel recommends that the sediment maximum Chromium Total concentration should be 60 mg/kg dry weight, and that the water quality standard in Hardy Bay, freshwater streams and rivers affected by the plant be maintained at 2 ug L^{-1} chromium, or baseline levels, whichever is the higher.

31. Pending publication of new comprehensive British Columbia "Receiving Water Quality" guidelines, the Panel recommends that ambient water parameters for trace elements in the fresh and marine waters in the vicinity of the site should be maintained at baseline levels or at the values in Table 3-E, whichever are lower. Furthermore, the Panel recommends that the sediment values "BC MoE Objectives" of Table 3-D be adopted.

32. It is recommended that approval of this project be conditional on satisfactory analysis, based on final air dispersion modelling, to demonstrate that depositional impacts to water and sediments are within the levels given in Tables 3-D and 3-E.

33. It is recommended that the proponent be required to provide hydrological data to the Ministry of Environment, and that this data adequately demonstrate that water table penetration and contamination will be avoided through appropriate design of storage facilities.

34. It is recommended that, to the greatest extent possible, the plant design and construction must retain the natural vegetation of the site. This should include the retention of a shoreline buffer of vegetation and sufficient tree retention elsewhere so as to screen the plant from view as much as possible.

35. The Panel recommends stack location should be carefully assessed in order to mitigate possible impacts to nearby vegetation.

36. The Panel recommends that the Chromium VI special waste leachability figure of 0.1 mg L^{-1} (B.C. MoE) be regarded as total soluble chromium, consistent with the analysis of the CrIII/CrVI speciation question rendered in this report.

37. The Panel recommends that leachate tests should be performed on a simulated sample of the slag before the waste permits are issued for the plant. If it is determined that the slag exceeds leachability criteria, so as to be classified as "Special Waste",then it should be a condition of permitting that the Ministry of Environment be provided with and approve a plan to handle this material in a manner that does not pose a hazard.

38. It is also recommended that regular leachate tests be conducted on slag produced during the operation of the plant.

39. It is further recommended that the possibility of significant entry into the water table and hence the terrestrial environment must be avoided by using "hardened" sites for slag storage. This includes containment by berming and peripheral runoff collection systems.

40. It is recommended that facilities for handling such solid wastes and for safe storage of these materials on site must be addressed by the B.C. Ministry of Environment and by the proponent.

41. The Panel recommends that if government determines that the proponent may proceed with the Bear Cove site, then all of the foregoing recommendations and the recommended monitoring program, as outlined in Section 5, should be applied.

Social Issues

1. In consideration of enhancing public confidence, the Panel recommends that the B.C. Ministry of Environment be closely involved in all aspects of the establishment and monitoring of the standards which this report recommends for this project.

2. In addition, we recommend that the British Columbia government ensure that the Ministry of Environment has available the resources and personnel to fulfil the specific tasks which have been referred to them under the Waste Management Act and the Environment Management Act.

3. It is further recommended that the monitoring program be coordinated and supervised by the Ministry of Environment, that the proponent bear the costs of this monitoring program, and that there be full, open and timely supply of monitoring information to the public, through a locally-based committee of interest groups.

4. The Panel recommends that the Ministry of Environment coordinate the formation of this locally based monitoring committee. It should be funded through the proponent's permit fees or a similar arrangement made for proponent sponsorship.

5. It is further recommended that participation in this monitoring committee should include the principal government agencies, as well as representatives from local organizations (including native groups) concerned with this issue.

6. It is recommended that, as a condition of approval, the proponent be required to post a bond or other such security (acceptable to the Ministry of Environment) of a magnitude sufficient to provide for any clean-up operations that can be anticipated in a "worst case scenario" and to provide compensation to parties who might be adversely effected. The magnitude of this security should be determined by the Ministry of Environment.

7. It is recommended that the proponent take every reasonable effort to hire as many as possible of its employees from both the native and non-native communities of the region.

8. The Panel recommends that the provincial government carefully review the entire issue of the power rate offered to Sherwood at Nanaimo as to the extension of this offer to any other location. Consideration should be given to financial analyses (beyond the mandate of the Panel) in regard to the proponent's need for this reduced power rate and the duration of the discount.

9. It is recommended that the final design of the buildings and the stack must have a minimal visual impact on nearby communities or recreational areas.

10. Notwithstanding the project's other merits, including its manageable environmental impact and its net social benefits, this Panel recommends that this project not be authorized on the selected site until such time as an agreement can be reached between the proponent and the native people, or until the outstanding land claim and treaty issues have been resolved by litigation or settlement.

Monitoring Program

1. It is recommended that a comprehensive monitoring program be required, including baseline studies, start-up monitoring including stack testing, sampling locations and protocols, monitoring guidelines, and plant shutdown specifications, as outlined in this report (Section 5).

2. The following baseline requirements are recommended:

(1) Sufficient baseline data, particularly on the existing marine ecosystem in order that any changes induced by the facility can be detected following start-up.

(2) Meteorological data, especially in terms of extent of data gathered in communities in proximity to the plant.

(3) Physical oceanographic baseline data on Hardy Bay. In particular data from stations A and B was judged to be inadequate by the Department of Fisheries and Oceans and Environment Canada. This should be a one year program (Lewis: file 361-Pan/Ex.26).

3. In conjunction with the B.C. Ministry of Environment, and as a condition of the permitting process, the Panel recommends that:

(1) Emission and effluent limits must be set, rather than using objectives or guidelines.

(2) Prescriptions for action (i.e. shutdown), or penalties, or emergency procedures (such as storage of effluent) must be set in conjunction with the emission and effluent limits.

(3) There must be specification of actions to be taken when pre-set levels of impact on the receiving environment are reached. These should be specified either in concentrations of contaminants (ambient air and water quality), or effects on ecosystems. The latter may be "no effects" levels, particularly for the productive Quatse River estuary. These would be specified for air, soil, sediment and biota.

(4) Procedures and contingency plans must be submitted for maintenance, emergency and major failure situations that would require shut down or other such action.

(5) In view of the novel technology and developmental aspects of this plant, reporting mechanisms for routine informing the Ministry of Environment of such incidents (failures) should be established for a five year period.

(6) Government authorities must institute surveillance of the project and appropriate enforcement procedures. These should include:

a) Regular collection of test results, including a special one year study of chromium levels from air emissions, effluent, and leaching of slag and raw materials.

b) Unannounced sample collection by the Ministry of Environment, with independent analysis (including air, effluent and environmental samples -- biota, sediment).

c) A quality assurance/quality control review by the Ministry of Environment, including assessment of low level (trace) chromium test procedures. An outline of relatively conventional requirements is given in file 449-Pro.78. It is particularly important for the Ministry to make an assessment of the following:

i) detection levels in the proponent's procedures (especially chromium);

ii) quality assurance/quality control on leaching tests of slag and raw materials, particularly with respect to precision and accuracy;

iii) sampling protocols for biota and sediment, particularly in relationship to hypothesis targets for surface sediment layers and habitat locations.

(7) There must be an investigation of CrVI/CrIII operational levels and bioavailability (solubility of chromium in acid and base) after operational levels are reached and during the start-up phase.

(8) Finally, it is recommended that a focused, rationalized monitoring program must be designed that makes hypotheses on environmental impacts, designs a specific slate of samples and analyses to test them, and then provides action levels and remedial actions.

4. It is recommended that public exposure to contaminants should be monitored by the following methods:

(1) Air monitoring in Beaver Harbour and Port Hardy, including total chromium analysis: Consideration should be given to frequent 24-hour high volume sampling in these locations. Dustfall samples should be subjected to CrVI/CrIII ratio analysis during the phase-in of the plant.

(2) Regular analysis of the public water supply for municipalities affected, including source and after-treatment sampling.

(3) Determining the coliform count in the vicinity of the seawater cooling outfall regularly, and transmitting the data to the public health office in Port Hardy. In this context, Sherwood must provide sewage dispersion information for the outfall when the heat exchanger system is not functioning.

(4) Monitoring the noise impact from the plant on surrounding residential communities, using measurements before and after commissioning. The proponent has undertaken to make such measurements. The public health office should assess effects.

(5) Monitoring for odour: The potential for odour is almost entirely in regard to "TRS" (total reduced sulphur), or H_2S in this case. Exclusion of this nuisance should be confirmed, based on start-up tests on slag quenching (cooling); these would be run by the proponent.

(6) Determining residual risk to human populations of Chromium VI, as a known carcinogen: This analysis would optimally be based on modelling projections, with the data obtained as outlined above.

5. It is recommended that Sherwood implement a workplace hazards program, in cooperation with the Workers Compensation Board, that addresses issues such as the safe storage of hazardous materials (solvents, gasoline, chemicals) and protocols for spill clean-up to protect workers and to prevent excursions of contaminants and pollutants into the environment.

(1) The Panel recommends that the Workers Compensation Board re-assess the use of the TLV value, with a view to adopting the more conservative workplace ambient level of 0.05 ug/Nm^3.

(2) Furthermore, it is recommended that worker health and safety education, and the acquisition of baseline health information about the workers, should be undertaken as priorities during start-up.

(3) Finally, it is recommended that appropriate monitoring of chromium levels in employees before and after start-up should be undertaken.

6. As a new standard of major industrial project planning, the Panel recommends that contingency plans be established from the initiation of the Sherwood project to cover both short term and long term shut-down of operations.

7. It is recommended that for short term shut-down, the following measures should be required:

(a) the continued monitoring and treatment of storm water, including run-off from stockpiled raw materials, slag and waste;

(b) site clean-up of all exposed material before or at the time of a shut-down;

(c) continued analysis of storm water during the shut-down period, unless there is sufficient storage capacity to retain all run-off (for example, during a two week holiday period);

(d) in the absence of a full site clean-up, continued operation of the full analytical and water treatment facility on a standby basis, if storage capacity for the shut-down period is not available;

(e) provisions written into waste permit conditions ensuring that the financial resources will exist to carry out the monitoring and clean-up work necessitated by shutdown; this may necessitate the posting of a suitable financial bond.

8. It is recommended that, in the event of long term shut-down, all wastes, raw materials, chromium-bearing slag (and other toxic elements) should be appropriately disposed of, and there should be final water table and soil testing to complete the shut-down work.

1.0 INTRODUCTION

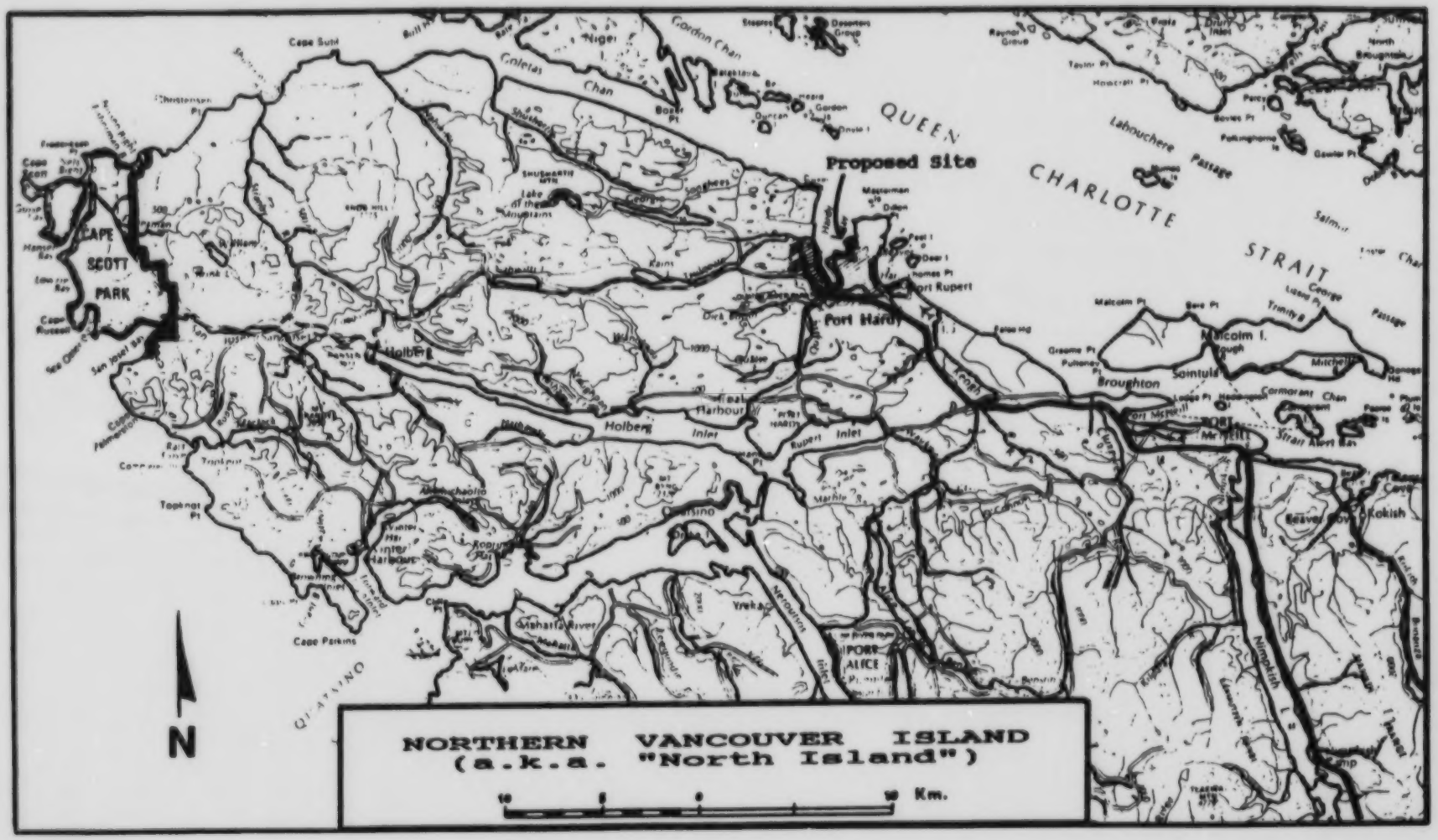
1.1 THE PROJECT UNDER REVIEW

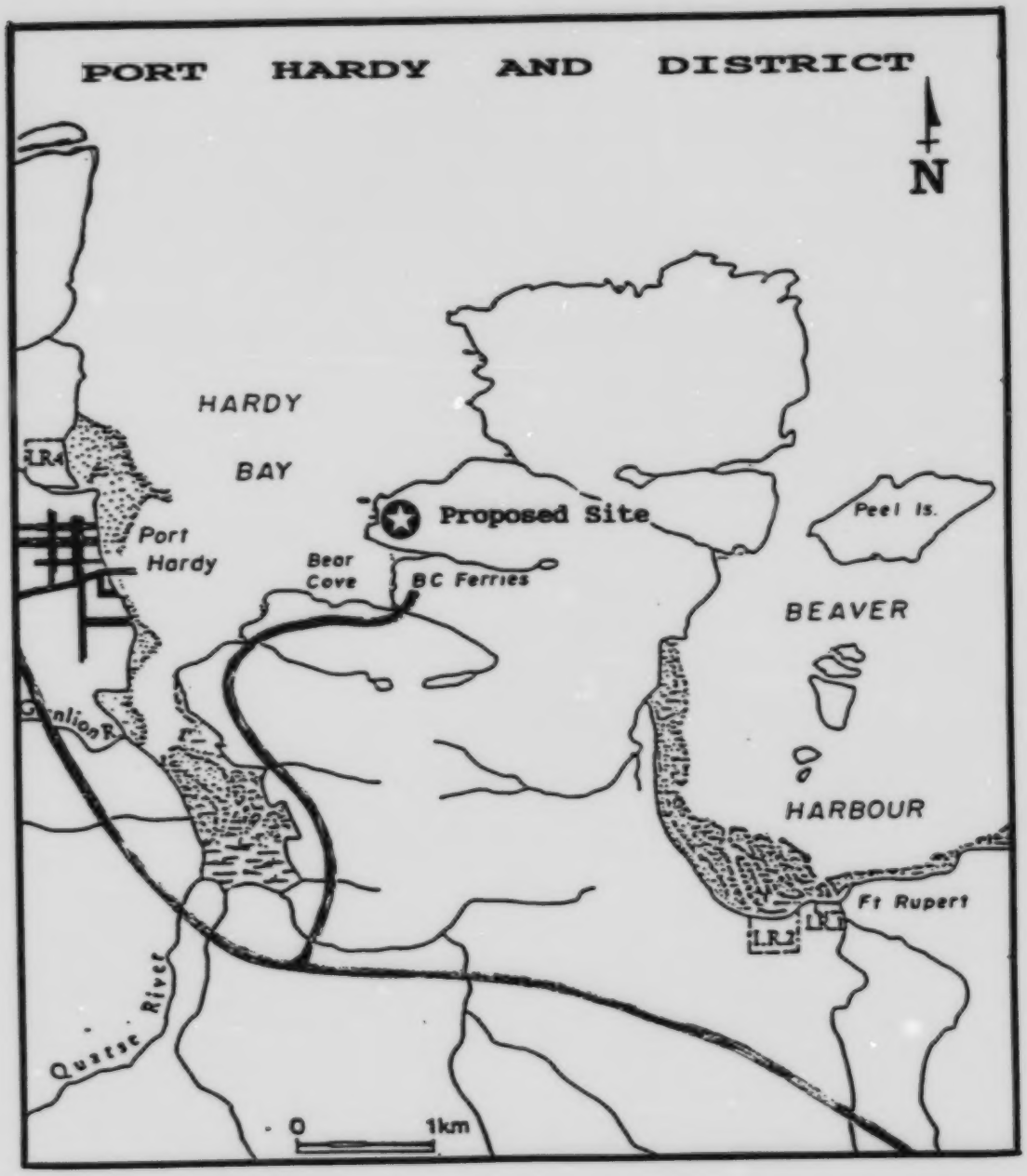
1.1.1 Overview of the Proposal

Sherwood Metallurgical British Columbia Corporation (Sherwood) proposes to construct and operate a low carbon ferrochromium smelter and refiner in the vicinity of Port Hardy, on the northeastern coast of Vancouver Island, British Columbia. This facility would produce ingots of a high quality low carbon ferrochromium for use elsewhere in the manufacture of special steel alloys. As a by-product from the metallurgical process, it is also proposed that a fibre insulation and reinforcing product, referred to as "Sherglas", would also be produced at this plant.

Sherwood was attracted to this Province because of a combination of factors: (a) sheltered, deep water port capabilities; (b) comparatively inexpensive waterfront land in certain locations; (c) availability of hydroelectric power at low rates; (d) availability of a suitably skilled labour force; and (e) financial assistance from the senior governments of British Columbia and Canada in the form of special loans totalling $9.75 million. The hydroelectric and capital incentives will be dealt with in more detail in this report.

Western Economic Diversification Canada initially advised Sherwood of a selection of possible locations for the plant. From these, Sherwood first selected a site near Mill Bay, on the southern end of Vancouver Island. This initial proposal, commencing in early 1988, was subjected to a series of financial, engineering and environmental analyses sponsored by departments and ministries of the governments of Canada and the province. Most of these studies (excluding financial reviews) were submitted by the governments to this Panel as background information. After two public meetings in late 1988, where concerns were expressed regarding the nature of the proposed use on


Proposed Site
QUEEN CHARLOTTE STRAIT
CAPE SCOTT PARK
Port Hardy
Port Rupert
Holberg
Holberg Inlet
Rupert Inlet
Broughton
Malcolm I.
Port McNeill
Beaver Cove
Kokish
Port Alice
Cape Parkins
Quatsino
Cape Sutil
Lahouchere Passage
Cormorant Chan
Gordon Chan
Ginletas Chan
N
NORTHERN VANCOUVER ISLAND
(a.k.a. "North Island")
Km.


PORT HARDY AND DISTRICT
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the site, the Capital Regional District made certain conditions necessary for rezoning to occur, prompting Sherwood to abandon interest in the site.

The second site investigated by Sherwood, in early 1989, was at Jack Point in Nanaimo. This site was already zoned appropriately. A number of studies were conducted, the federal and provincial governments issued approvals-in-principle, and a special hydroelectric rate structure was arranged. By the Fall of 1989, mounting public pressure on the local municipal council resulted in a request that this project be subjected to a full environmental review. Sherwood, aware that such a review would be site-specific, requested the opportunity to determine its most preferred site, before the review commenced.

In early January 1990, Sherwood announced that it had selected a site adjacent to the district municipality of Port Hardy as its most preferred site. Apparently, this was one of perhaps three sites that the Port Hardy municipal council had suggested as possible locations.

On January 12, 1990, the federal and provincial Ministers of Environment jointly announced the appointment of this environmental review panel to examine the full environmental and social implications of the proposed plant.

1.1.2 The Position of the Proponent

Sherwood, the proponent, has presented evidence to this Panel through its representatives Mr. R. Snow and Mr. D. Searle of Davis & Company, Vancouver.

At Port Hardy, Sherwood proposes to produce high grade low carbon ferrochromium at a rate of 25,000 - 30,000 tonnes per year. This equates to about 10% of the current world market for this quality of product. The proponent also proposes to utilize the slag waste from the smelter to produce the mineral fibre by-product, "Sherglas".

During this review process, the proponent has filed 100 documents with the Panel, which has examined all of them. The proponent's principal documents are, in their sequence, as follows:

"Sherwood Project: Initial Submission"
File 52-Pro.5; received 28/02/90.
"First Supplemental Submission"
File 77-Pro.6; received 16/03/90
"Second Supplemental Submission"
File 78-Pro.7; received 16/03/90
"Third Supplemental Submission"
File 89-Pro.10; received 27/03/90
"Fourth Supplemental Submission"
File 128-Pro.11; received 31/03/90
"Fifth Supplemental Submission"
File 173-Pro.15; received 02/05/90
"Environmental Impact Statement"
File 183-Pro.17; received 10/05/90
"Environmental Impact Statement: Addendum Report"
File 335-Pro.33; received 27/08/90
"Sixth Supplemental Submission"
File 546-Pro.44; received 15/11/90
"Seventh Supplemental Submission"
File 544-Pro.91; received 09/11/90
"Final Submission"
File 559-Pro.95; received 27/11/90

Sherwood claims that its process is a considerable improvement on conventional smelting and refining technology, using less than half the energy and fully enclosed furnaces. Sherwood also claimed that by converting the slag to a saleable mineral fibre product, solid waste would not accumulate on the site.

The documents noted above contained a wide range of claims relating to the process technology, the environmental impact, and the social impact of this project. These positions of the proponent are presented and analyzed in the appropriate sections of this report.

Throughout the unfolding history of the Sherwood proposal in British Columbia, the proponent has suggested that additional phases might be developed in unspecified years. This Panel has considered, and this report deals with only the first phase of this Sherwood operation with a total production of 30,000 tonnes or less per year.

1.1.3 Positions of Concern

From the first introduction of this proposal, on southern Vancouver Island, there have been groups and individuals expressing concern. With respect to the Port Hardy site, the positions of concern have been represented chiefly by the following groups:

(1) The Kwakiutl Band and the Kwakiutl District Council; represented by Mr. Kim Roberts (Nadler, Roberts & Lee), Mr. Karl Sturmanis (Kwakiutl District Council staff), and Mr. Basil Ambers (Kwakiutl spokesperson).

(2) The Concerned Residents of the North Island; represented by Mr. Calvin Sandborn (West Coast Environmental Law Association)

(3) The United Fishermen and Allied Workers' Union; represented by Ms. Kate Brauer (Sointula resident).

(4) The Malcolm Island Environmental Protection Society; represented by Mr. Ralph Harris (Sointula resident) and associates.

In addition to and in support of these, many other groups and many individuals have made written and oral submissions to this panel.

It is a public concern that the plant, as designed to function at Port Hardy, is based more upon theory and engineering data rather than actual pilot plant data. It is observed in many submissions to the Panel that the design of the plant has not been sufficiently finalized, particularly with respect to the presence and height of a stack, the presence of a dedicated docking facility, the production of Sherglas mineral fibre, the accumulation of slag, and the content and effects of emissions.

There have been concerns expressed with regard to the proponent's ability to satisfactorily accomplish plant design and operation, environmental protection, and proposed production rates. Concerns have been stated regarding the economic viability of the project, and the implications of plant abandonment for the local environment.

Many submissions express the view that this project would be an intrusion into the existing resource related economy and non-industrialized environment of the region that would bring the risk of irreversible change to the way of life enjoyed there. There is worry about possible impacts upon the visual quality of the landscape, the freshwater and marine life, and the potential for expansion of tourism. Most significantly, there is considerable concern that this plant could pose a risk to the health of the residents, and could otherwise reduce the quality of life in this area, as consequences of the emissions and effluents.

Another major concern is that too little is known about the natural environment in the vicinity of the proposed plant. It is claimed that the marine environment and nearby estuarine environment are biologically productive and sensitive zones. These areas, it is claimed, are important areas for food gathering and should not be put at risk.

The toxicity of chromium is a prominent concern with regard to human health, soil, freshwater and marine life. The principal source of chromium pollution would be the fine dust emitted from the plant's stack. It is claimed that there is insufficient knowledge about the toxicity of chromium, and that various authorities have identified some forms of chromium as highly toxic and carcinogenic.

The native people, chiefly the Kwakiutl Band, supported by the other bands of the region, are concerned that this plant would be an unacceptable intrusion into and disruption of their rights to hunt and fish in this area, and would therefore conflict with the terms of the "Douglas Treaty". Moreover, they claim that the land has cultural significance as a former area of habitation, and therefore may not have been relinquished under that treaty. Finally they assert that the entire area is included within the area encompassed by their land claim, and therefore no further land use decisions should be made until that claim is resolved.

It must be stated here that, as a summary of the concerns, the above comments should NOT be assumed to either entirely represent the positions of concern or to accurately reflect the complete nature of the project or the abilities of the proponent.

1.1.4 Positions of Support

The principal parties in support of the project are:

(1) The municipal council of the District of Port Hardy, represented by Mayor Al Huddlestan;

(2) The municipality's Economic Development Committee, represented by Mr. Brian Klaver

(3) The community organization known as Just People, represented by Ms. Linda Hancock.

The primary position of support is that this project should be allowed to proceed if, through this review panel's deliberations, it is determined to be environmentally acceptable. If this is shown to be the case, it is proposed that a community-based group should be established to ensure that monitoring and regulation occur as prescribed.

Supporters of the project argue that the region needs greater economic diversification. This is said to be particularly true in light of the threat of the closure within a few years of the nearby Utah Mine, which employs over 500 people at this time.

Many individual residents of the Port Hardy area indicated to the Panel that they favour the project if it is shown to be environmentally acceptable.

1.1.5 Government Participation

In addition to initiating this review, the federal and provincial governments participated in the process in respect of specific legislative mandates concerning this kind of development project, environmental protection, land use, energy supply, and native issues. A number of agencies of government (including crown corporations) participated directly in this review, assisting valuably in providing information and in examining the proposal. The major government participants include:

(1) The federal Department of Fisheries and Oceans; represented by Mr. R. Higgins (Nanaimo office).

(2) Environment Canada; represented by Mr. J. Millen (Vancouver office).

(3) The British Columbia Ministry of Environment; represented by Mr. E. Warnock, regional director, and staff of the Vancouver Island Regional Office (Nanaimo).

(4) The B.C. Ministry of Agriculture and Fisheries; represented at the hearings by Mr. J. Truscott (Victoria office).

(5) The B.C. Hydro and Power Corporation; represented at the hearings by Mr. Loewen (Vancouver office).

In addition, brief appearances were made by the Ministry of Crown Land (represented by Mr. K. Baker), the Ministry of Municipal Affairs, Recreation and Culture (with Mr. R. Kenny representing the Outdoor Recreation and Archaeology Branch), the Ministry of Native Affairs (represented by Ms. C. McNichol), and Western Economic Diversification Canada (represented by Mr. C. Heartwell).

1.2 MANDATE OF THE REVIEW PANEL

The Review Panel was established on January 12, 1990 by the federal and provincial ministers of environment. It consisted of Vancouver lawyer Bryan Williams, Q.C., serving as chairman, George Davies, a metallurgical engineer, and Dr. Paul West, a chemist and director of the University of Victoria's Environmental Studies Program.

The Review Panel was established under the British Columbia Environment Management Act in order to conduct a full and formal review guided by the federal Environmental Assessment and Review Process ("EARP"). Under the Environment Management Act, the Panel chairman also has powers under the B.C. Inquiries Act, particularly with regard to the ability to subpoena information and witnesses. The overriding objective of an EARP, as a review process, is to conduct a thorough and fair, formal, non-judicial investigation, including technical analysis, public submissions, and public hearings.

The full terms of reference are included as Appendix A in this report. The core of the mandate is expressed in the following excerpt:

> "The mandate of the Panel is to conduct a public review of the environmental and social effects of this proposed ferrochromium plant at Port Hardy. The Panel shall identify the impacts associated with the proposal, assess their significance and investigate options for their reduction or elimination. Specifically, the Panel shall address the potential social impacts, including those relating to employment, regional development and recreation. Environmental impact to be reviewed should focus on construction impacts on the local ecosystem, the potential impacts of raw material storage and handling, the process technology, and all wastes or by-products associated with the process. Thorough consideration shall be given to the proposed waste treatment and handling methods, including the use of salt water or water to air discharge for the process cooling. Specific attention is to be paid to the toxicity of all materials that will be exposed to or discharged to the environment.
>
> "In fulfilling its mandate, the Panel shall provide full opportunities for the public review and comment, including public hearings to be held in the Port Hardy area.
>
> "Upon completion of its review, the Panel shall provide a written report and recommendations to the federal and British Columbia Environment Ministers on the environmental acceptability of the proposal. Recommendations shall be provided on the environmental and social acceptability of the proposed ferrochromium production technology and the specific application of this technology at the Port Hardy site ..."

Based upon these terms of reference, the Panel considered that its review should include:

(1) the process technologies (including pollution control) in order to determine their feasibility and suitability and the potential environmental impacts;

(2) the potential impacts on the air, the freshwater, marine and foreshore environment and the terrestrial environment;

(4) potential health impacts on humans;

(5) economic costs and benefits for the local area and the Province;

(6) pertinent special social issues;

(7) overall project viability in order to assess the risk of plant abandonment; and

(8) terms and conditions for the plant that, should it be built, would ensure that it would not adversely affect human health or the environment.

Assisting the Panel to carry out their mandate were Mr. Murray Rankin, as panel counsel, and Mr. Ken Youds, as secretary to the Panel.

1.3 THE PUBLIC REVIEW PROCESS

In accordance with its mandate, the Panel reviewed the pertinent sections of appropriate British Columbia statutes, including the Environment Management Act, Waste Management Act, and Inquiry Act. As well, the federal Environmental Assessment and Review Process (EARP) Order-in-Council and related procedures, rules and guidelines were carefully examined. The procedures adopted by other such panels with similar mandates were also studied.

From this material, the Panel developed its own process and operational procedures. These are provided in full in Appendix B.

Public Access to Information

Full public disclosure of all information submitted to and available to the Review Panel was considered essential from the outset. Other than its own internal business meetings, the Panel's meetings were all open to the public.

All submissions and other documents available to the Panel, unless already in the public domain (i.e. published elsewhere), were copied and distributed to selected public reference centres in the North Island region, in Vancouver, in Nanaimo and in Victoria. Major reports published elsewhere that were submitted to this panel were not recopied, in respect for copyright protection and in consideration that these were already in the public domain and readily obtainable. Appendix C is a list of these "Reference Documents".

In total, the Panel received and distributed to the public reference centres about 575 submissions. About 100 of these were submitted by the proponent, and the proponent was directly responsible for distributing its major technical submissions (nine documents in all). Individuals and groups from the public filed roughly 250 documents with the Panel. Government agencies filed 60 documents.

All significant submissions (i.e. submissions of substance from any of the participants and the proponent) were copied and distributed to all identified interest groups and offices.

Following the hearings, copies of the transcripts (on computer disks) were provided to a reference centre in Port Hardy, Sointula, Alert Bay, Nanaimo, Victoria and Vancouver. As well, each registered participant group's counsel, including the proponent, received a copy of the transcript. As computer disks, these were provided free of charge in order to lessen the cost of production and to render them more accessible.

Panel's Orientation

The Panel's orientation consisted of three elements: examination of background documents, an orientation visit to the site and the region of the proposal, and an orientation tour of selected metallurgical facilities in North America and visit to the United States' Environmental Protection Agency.

At the commencement of the review process, the Panel obtained a number of documents from the provincial Ministry of Environment and from the Western Economic Diversification Canada office. These had been prepared and filed in reference to earlier proposals and submissions by Sherwood. These documents were all filed as "Background Documents" with the public reference centres for this review.

On February 13, 1990, the Panel and its Secretary conducted an orientation visit to the site near Port Hardy and a tour of the surrounding area. The site was examined from the air using a helicopter. On a subsequent visit to the region, the Panel gained foot access to the site, and traversed much of the terrain covered by the proposal. During the February 13th visit, the Panel held informal public meetings in Port Hardy, Beaver Harbour/Fort Rupert, Port McNeill, Sointula, and Alert Bay. The purpose of these meetings was to introduce the Panel to interested members of these communities, and to introduce these community members to the basic procedures of the review to be conducted.

Subsequent to the public distribution of the proponent's "Initial Submission" (file 52-Pro.5)* in late February, the Panel conducted a series of public meetings in the North Island region. The purpose of these meetings was to "scope" (or identify) the issues that the review should address, and thereby to provide the proponent with detailed information requirements. These issue-scoping meetings took place between March 29 and 31, 1990 and were held in Fort Rupert/Beaver Harbour, Port Hardy, Alert Bay, Sointula and Port McNeill. In total, several hundred people attended these meetings and several score addressed the Panel. As well, representatives of the proponent attended these meetings. Following these meetings, on April 17th, the Panel provided a document to the proponent, entitled "Issues Identified for Consideration by the Proponent in Development of an Environmental Impact Statement" (file 149-Panel.8). This 20-page document was also distributed to all participant groups and reference centres.

In order to familiarize itself with aspects of the metallurgical industry pertinent to this review, the Panel visited several plants in eastern North America and the U.S. Environmental Protection

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* References to information on file with the Panel will show the file number and, where appropriate, a page number or other specific component of the particular file. Refer to Appendix D for an explanation of the file system and a complete index to the file system.

Agency offices in Washington, D.C. Specifically the following visits were made (a full account is contained in file 324-Panel.39):

SKW Canada at Becancour, Quebec:
Baghouse technology, electric furnace operation, ferrosilicon production. Principal contact: Mon. Denis Rodrique, Superintendent Engineering.

Atlas Steel at Welland, Ontario:
Stainless steel production, VOD (Vacuum Oxygen Decarburization), electric furnace operation and emissions. Principal contact: Mr. Thomas J. Parker, VP Purchasing and Government Relations.

Teledyne Vasco at Latrobe, Pennsylvania:
Electric furnace operation, AOD (Argon Oxygen Decarburization), baghouse technology. Principal contact: Mr. Peter M. Forsythe, Manager Special Projects.

U.S. Environmental Protection Agency at Washington, D.C.:
Standards and regulations concerning emissions from smelters, with particular attention to chromium species. Principal contact: Mr. Peter Christich, Office of International Activities.

Public Hearings

Full public hearings were conducted in the Port Hardy region. These included both the examination of technical evidence and submissions from community members and government.

The original date scheduled for commencement of the public hearings was in mid July, on the understanding that the proponent's Environmental Impact Statement would be delivered by May 2, 1990. On that date, the Panel received a document from the proponent entitled "Fifth Supplemental Submission" (file 173-Pro.15). This document provided, in the proponent's view, responses to the Panel's list of issues, but this was not the E.I.S. as prescribed. The E.I.S. was delivered to the Panel and distributed to the public on May 10th. This left only the minimum amount of time for its review by participants and little or no flexibility in respect of time to respond to any further information required. Nevertheless, on May 25th, the Panel issued a letter that advised the public and the proponent that it expected to commence the hearings on or about July 16th, 1990.

On June 18th, the Panel advised the proponent that there were many deficiencies in the E.I.S., which the Proponent would have to address immediately, or risk an adjournment of the hearings. During this time frame, many members of the public expressed concern to the Panel with regard to holding the hearings during a period when commercial fishermen were likely to be absent from North Island communities. In early July, further documents were filed by the proponent. The Panel

met on July 4th and determined that in consideration of the late filing of significant documents, continued deficiencies of information, and public concerns about the timing of the hearings, the hearings should be rescheduled. All parties were informed of this decision, and the proponent was further informed that the Panel expected that a comprehensive revision to the E.I.S. would be prepared and submitted.

Subsequently, the proponent advised the Panel that it would require the balance of July and much of August to prepare the necessary documentation. Based upon this advice, the Panel advised that the earliest date for the commencement of the hearings would be early October, depending on the date of filing of the requested addendum to the E.I.S. On August 27, 1990, the E.I.S. Addendum (file 335-Pro.33) was filed with the Panel and distributed to the participant groups. Based on this filing, the Panel announced that the hearings would commence on or about October 3, 1990.

A hearings schedule was subsequently prepared and distributed. It is located in Appendix E, and shows that these hearings commenced October 4th. Consistent with the published procedures, two types of hearings were arranged: community and technical. The purpose of "community" hearings was to give residents and the general public opportunities to provide their oral information or opinions. These somewhat informal sessions were held during evenings and weekends in Port Hardy, Fort Rupert/Beaver Harbour, Sointula, Port McNeill, and Alert Bay. These were very well attended, with individual sessions ranging in attendance from 30 to 400 persons. All who wanted to speak or ask questions were allowed time to do so. All community sessions were tape recorded for future reference.

The "technical" hearings, held on weekdays and generally during daytime hours, were organized such that registered participants, the proponent, the Panel's consultants, and representatives of government agencies had opportunities to present evidence or raise questions, were themselves examined on evidence presented, and had the opportunity to examine others on technical issues. The public and the Panel also had the opportunity to direct questions to presenters. These technical hearings were relatively formal and full transcripts were prepared from the proceedings. The last scheduled date for technical hearings was October 18th, however more time was required for the proponent to supply information requested during the hearings and for closing arguments to be presented. Therefore, in consultation with all registered participants at the technical hearings, the hearings were adjourned on October 18th and reconvened on December 1, 1990. On this date, the hearings were completed and adjourned. At the end of the hearings, there remained a few issues

which had not been completely addressed by the proponent and, accordingly, the Panel established December 7, 1990 as the final date for the proponent's response to matters raised at the last day of hearings.

Technical Assistance

Due to the highly technical nature of the subject of this review, each party required technical experts.

The proponent utilized its own technical expertise and retained a number of specialists and advisors in the many fields pertinent to the proposal, including metallurgy, chemistry, emissions, effluents, environmental impact, marine ecology, oceanography, public health, and socio-economics. Those who appeared before the Panel included:

Sherwood:
Mr. J. Wooding, President, engineer
Dr. P. Stewart, Director, chemical engineer
Mr. R. Pitchers, Project Manager, mech. engineer
Mr. R. Campoy, of Elders Resources Finance Inc.

Rescan Environmental Consultants Ltd.
Mr. C. Pelletier, chemist
Mr. R. Marsland, environmental engineer
Mr. M. de Spot, air pollution engineer
Mr. G. Birch, biologist
Dr. P. Griesman, oceanographer, environ. engineer
Mr. J. Werring, zoologist
Dr. T. Kessler, oceanographer
Mr. D. Flather, soil scientist
Mr. W. Duncan, biologist, entomologist

Other Consultants and Advisors
Dr. W. Hartford III, chemist
Dr. R. Fruehan, professor of metallurgy
Dr. A. Mitchell, professor of metallurgy
Mr. W. Hartung, President of Laxa Bruk
Dr. P. Bidstrup, medical health doctor
Ms. J. Bussey, archaeologist
Mr. R. Hornal, socio-economic consultant

The Panel retained, as its advisers, the following experts:

Dr. J.K. Brimacombe:
metallurgical engineer and professor at U.B.C.

Dr. E. Peters:
metallurgical engineer and professor at U.B.C., with knowledge of chromium metallurgy.

Dr. P. Sagert of Cirrus Consultants:
- engineer specializing in air emissions and dispersion modelling and regulation.

Dr. P. Chapman of EVS Consultants:
- marine and aquatic biologist specializing in environmental impact and monitoring.

Dr. A. Lewis:
- marine scientist and professor at U.B.C. specializing in oceanography and environmental impacts.

Dr. M. Shaffer of Shaffer & Associates:
- economist specializing in social and economic impact evaluation.

These experts were responsible for advising the Panel on technical matters, commenting on the technical reports filed by the proponent, providing a report assessing the proponent's submissions, and participating in the technical hearings. These duties were thoroughly carried out and all documents submitted were placed on the public files.

The Panel requested that the federal and provincial governments provide funding to the public participants in order that they could retain expert advice. This request was denied but the Panel used its discretion to retain an additional set of experts to assist the public participants in order to "effect a level playing field". The participant groups were invited to nominate appropriate specialists in the three fields of air emissions, marine ecology, and metallurgy.

As a result, the following consultants were nominated by the participants and retained by the Panel on behalf of the public:

Mr. W. Lemmon (C. Napier Company Ltd.):
- metallurgical engineer.

Dr. R. Caton (Concord Scientific Corp.):
- engineer specializing in air emissions and related matters.

Drs. W. Duval and D. Thomas of Seakem/ESL Ltd.:
- specializing in marine ecology and related environmental impacts.

These consultants were to provide technical assistance to all the participant groups. Like the other experts retained by the Panel, these experts provided analysis of the proponent's submissions,

submitted their own reports, and participated in the hearings. All their documents were placed on the public files.

In addition to these experts, the Panel requested and received (in most cases) special input from a number of government and related agencies. The following agencies were all placed on the information distribution system and requested to supply the Panel with specific or general information pertinent to the review:

B.C. Ferry Corporation
B.C. Hydro and Power Corporation
B.C. Ministry of Agriculture and Fisheries
B.C. Ministry of Crown Lands
B.C. Ministry of Environment
B.C. Ministry of Health
B.C. Ministry of Municipal Affairs, Recreation and Culture
B.C. Ministry of Native Affairs
B.C. Ministry of Regional and Economic Development
B.C. Ministry of Tourism
B.C. Worker's Compensation Board
Environment Canada
Department of Fisheries and Oceans (Canada)
Western Economic Diversification Canada

2.0 PROCESS TECHNOLOGY

This review has included examination of all aspects of the process technology. This includes (1) the delivery, handling, and storage of raw materials; (2) the preparation of feed materials; (3) the smelting process; (4) the refining process; (5) slag handling and processing; (6) mineral fibre production; and (7) ancillary operations, including pollution control. The conclusions of this section are limited to assessment of the general suitability and feasibility of the technologies proposed.

2.1 RAW MATERIALS

Composition

The production output of the Sherwood plant is given to be 30,000 tonnes per year of low carbon ferrochromium. To produce this, the following supply of raw materials is required (EIS Addendum: file 335-Pro.33):

Chromite fines	66,300
Anthracite	13,750
Quartzite	12,300
Lime	9,000
Total	101,350 tonnes per year

From this process, slag is produced at an annual rate of 44,100 tonnes. In order to convert all of the slag to Sherglas fibre (about 81,500 tonnes) additional raw materials would be required in the following amounts:

Silica	23,700
Lime	6,400
Alumina	8,250
Total	38,350 tonnes/year

Therefore, total bulk raw material requirements are estimated to be about 140,000 tonnes per year. In addition, a small quantity of aluminum metal would be required in the VAOD refiner. In addition, oxygen and argon requirements would be respectively 3460 and 3800 tonnes per year.

Chromite will almost certainly be imported from overseas. Oregon was also given as a potential future source but none is produced there at the present time. Anthracite (low sulphur) will either

be imported from overseas or the United States, and the other raw materials can be obtained from domestic or United States sources. The proponent has stated that ships would arrive approximately six times per year. (Transcript, p.89). The material which has sparked greatest public concern is chromite ($FeCr_2O_4$). Most experts attest that this is an inert and stable mineral, as indicated by its unaltered form occurring over millions of years in laterites and other rocks. (Dr. Peters' report: file 320-Pan/Ex.19). Dr. Nriagu of Environment Canada presented the view that under certain conditions the ore was soluble.

Potential sources of chromite ore for the Sherwood plant include India, Turkey, the Philippines, Indonesia, Alaska, and Oregon. Concern has been expressed that one leachate test, which was repeated, indicated that ore from Indonesian source may be subject to leaching. Specifically, one test yielded 0.140 mg/litre chromium concentration in simulated rainwater (File 183-Pro.17, p.4-15). It is known that the Indonesian ore is lateritic and therefore extremely fine-grained. According to Dr. Hartford, it is conceivable that such a material could pass through the 0.45 micron filter used for the tests. (Transcript, pp.341-342). These unexplained observations represent an area of uncertainty for the Panel. The proponent has indicated that they would conduct appropriate leaching tests on chromite ores and ensure that ores used in the smelter pass these tests.

Handling of Raw Materials

During the course of this review, the proponent has suggested that, as an interim cost-saving measure, it would be possible to use other commercial docking facilities in the vicinity, rather than construct a dedicated docking and off-loading facility for this plant. Considerable concern was raised by this suggestion, to the extent that the proponent made a later commitment (Dec.1 transcript, p.3260) to provide a dedicated docking and off-loading facility.

Much concern has been expressed over the spillage of raw materials into the sea during unloading of ships or barges at the proposed ferrochromium smelter. This concern is shared by the Panel. Many ore and coal unloading installations, as well as for other materials, are in operation throughout the world and work more or less efficiently depending on their design, maintenance practices, and operator skills. Dust and spillage always occur during the unloading, conveying and storage of bulk raw materials where special measures are not used to enclose them. This is especially so with fine materials, as would be the case with the Sherwood project.

It has been estimated by the proponent that up to 0.1 % of the raw materials could be lost due to spillage at the dockside and elsewhere. This is equivalent to approximately 140 tonnes per year, of which up to 66 tonnes could be chromite ore.

The proponent has advanced various design options for unloading vessels at dockside. The proponent's preference is to use a clamshell bucket to lift the materials from the ships or barges, discharging them into a hopper feeding a conveyer belt system. At the loading end of the conveyor, one proposal is to utilize a skirt system (designed tarpaulins) to contain spillage. This system is not widely used and spillage will vary depending on operator skill and operating conditions. Excessive spillage into the skirt or differential movement between the ship and the docking barge could cause it to rupture. It is not clear how this skirt will be emptied or cleaned during or at the conclusion of off-loading.

The method of dealing with spillage in the conveyor galleries has not been fully addressed. If the material is washed down, collection sumps will be necessary at various points including the dockside. Fugitive dust emissions will be collected in the No.2 baghouse and recycled in the process. Dust laden effluents from the sumps will be treated in the water treatment plant.

From the dockside, raw materials are to be transported by covered belt conveyor to the raw materials storage area which, in the most recent site design, is combined with the storage of other materials. This facility has been sited away from the shore area where it was formerly located. The proponent describes this as covered storage, but the type of covering and its ability to protect the materials from rain and wind has not been clarified by the proponent and remain a concern.

Conclusions and Recommendations

The Panel recommends that, in view of the controversy surrounding the solubility of chromite ore, samples of all chromite ores should be subjected to leach testing before shipment to the plant.

The Panel recommends that the proponent be required to build and operate a dedicated docking and off-loading facility from the commencement of the project, in order to assure effective control of the raw materials.

The Panel recommends that a reliable, acceptable scheme for off-loading must be designed that sufficiently minimizes spillage to meet stringent sediment guidelines. This will require considerably more engineering effort.

It is recommended that, from the dock to the storage area, the conveyor system must be covered and there must be dust extraction hoods and water spray at transfer points in accordance with accepted engineering practice.

It is recommended that, before proceeding with construction, the final raw material handling and storage scheme be approved by the appropriate ministries of government, with the objective that it must satisfy those bodies that the opportunities for spillage and other losses of material to the environment are sufficiently minimized.

It is recommended that the storage facility should be a fully enclosed building in order to prevent wind losses and any potential leaching from the storage site.

2.2 MATERIALS PREPARATION

Materials from the storage area would be transferred to a feed bin within the process plant building. Materials handling from the storage area to process bins within the plant is standard engineering practice and not an issue of concern.

The feed bin would feed the materials (ore, coal, silica, lime) to a rotary dryer to reduce the moisture content to a level acceptable for smelting. Dried raw materials would be separately stored in a series of feed bins from which they would be proportionately drawn to give the correct mixture for smelting. It is understood, although not shown on the process diagram provided by the proponent, that the raw materials would be briquetted, together with recycled dusts from the baghouses and elsewhere. Handling of recycled baghouse dust is not described but because of its fine size and dryness, extreme handling precautions need to be taken. This is particularly true in view of the projected accumulation of arsenic, zinc and other elements in the recycle.

The briquettes would be charged to the smelter (the so-called "primary melter") through a lock system which prevents ingress of air during charging. The total charge required to produce 5510 kg/hr. of high carbon ferrochromium is as follows:

chromite	11,050
anthracite (low sulphur)	2,289
silica	2,050
lime	1,500
total:	16,889 kg/hr.

Dust collector hoods are provided in the design at all feed, discharge and transfer points. This dust, along with other fugitive dusts, would be collected in a separate baghouse (No.2). It is noted that the experience of the stainless steel industry is that proper handling of this dust requires appropriate techniques. Notwithstanding, collection efficiencies do not often exceed 70% in practice.

Conclusion and Recommendation

The Panel concludes that the proposed materials preparation system is feasible and appropriate technology and agrees with the proposed method of preparing raw materials for charging into the primary melter.

It is recommended that the system for recycling the baghouse dust must be totally enclosed and that the technology for recycling baghouse dust (potentially contaminated with arsenic, zinc and chromium) must eliminate fugitive dust emission, based on Best Available Control Technology (BACT) in current use.

2.3 THE SMELTING AND REFINING PROCESS

The metallurgical principles to produce high carbon ferrochromium in the first stage of the process are the same as those used in conventional ferrochromium production. In essence, this involves the smelting of a mixture of chromite, lime and silica with carbon, using electricity as the heat source, to produce metal and slag.

The products from the smelting process (file 335-Pro.33, p.3-6) would be:

high carbon ferrochromium 5510 kg/hr.
(expected composition of 64% Cr, 21% Fe, 6% C, 3% Si)

slag 7347 kg/hr.
(containing the non-metallic constituents of the charge to the process: principally lime, magnesia, silica and alumina with small amounts of chromium expressed as Cr_2O_3 (1.9%) and sulphur (0.13%)

gas 3992 kg at 1700°C
(consisting of 98.7% carbon monoxide)

dust 40 kg/hr

The second stage of the process involves the use of a Vacuum-Argon-Oxygen-Decarburization (VAOD) furnace to remove carbon in order to yield low carbon ferrochromium. This stage does not differ in principle from conventional systems. However, Sherwood's furnace design does differ markedly from other systems, as it is a spherical vacuum-tight vessel. Molten high carbon ferrochromium is decanted into the refining vessel and is injected with an oxygen/argon mixture to remove carbon (as carbon monoxide) and silicon. Small additions of lime and aluminum metal may be made. The aluminum converts Cr_2O_3 to chromium, thereby minimizing CrVI formation. These additions also help control temperature rise. The vacuum is created by a steam ejector vacuum system which cools the off-gases from 1700°C to about 100°C, at the same time collecting most of the particulates, including any alkalis which may be present. During the refining, residual nitrogen in the metal is also removed.

The products from the VAOD refining process (file 335-Pro.33, p.3-9) would be:

low carbon ferrochromium 5000 kg/hr
(expected composition of 70.3% chromium, 29.7% iron, and 0.01% or less of carbon)

slag 392 kg/hr
(containing about 90% silica, 8.7% alumina, small amounts of chromium (Cr_2O_3, 0.90%) and lime. This slag would be recycled to the smelter.)

gas 1346 kg/hr

dust 15 kg/hr

The low carbon ferrochromium produced by this process would be a premium quality product relative to other such ferrochromium. Carbon content could be varied to meet specific customer requirements.

The features of Sherwood process which set it apart from conventional smelting and refining of ferrochromium include:

(a) careful measurement of the proportions of raw materials which are introduced as briquettes.

(b) closed furnace technology, giving a significant reduction in waste gas flow and a high level of control of emissions.

(c) spherical furnace shape which maximizes thermal efficiency and minimizes heat losses (low surface to volume ratio), resulting in an energy requirement that is about half that of conventional systems.

(d) furnace insulation to conserve energy and to allow temporary shutdown of the system with very slow temperature decline.

(e) utilization of carbon monoxide in the waste gases to generate steam to produce the vacuum used in the refining stage of the process and to dry raw materials and mineral fibre.

(f) precise instrumentation and electrical control.

Metallurgical experts agree that, while this is a new method of producing low carbon ferrochrome, most of the key elements of the process are in commercial use in the industry. There is agreement among metallurgists that the process will work (Brimacombe: Transcript, p.180) and, if optimal conditions have been attained, it is expected to work efficiently. It should be recognized that the commissioning process may take longer than envisioned by the proponent. (file 77-Pro.6, p.32: letter from Hatch & Associates)

In view of the novel design features of the Sherwood process, much concern has been expressed that no pilot plant work was done to produce ferrochromium. Specifically it is recognized that the furnace was tested at the ARBED steelworks in Luxembourg only as a melter of blast furnace slag and other materials. Dr. Brimacombe raised this concern from a technical perspective (file 230-Pan/Ex.5). He referred to "the lack of pilot plant data to provide a strong basis for assessing environmental impacts". The ARBED tests involved no environmental control or analysis of the off-gases.

Sherwood refers to three series of pilot plant tests in their Fifth Supplemental Submission (sec. II, ans.1). No details of the Special Metals Ltd. test in 1975\76 were given but a report of CANMET tests in 1979 was provided. These two units formed the basis for design of the unit tested at ARBED. The ARBED unit is described as a full scale prototype (Transcript, p.69). These trials in 1979-81 have been described in some detail in Addendum II of Sherwood's Initial Submission (file

52-Pro.5). Based upon a letter from an ARBED executive (file 41-BI.7, attachment), some critics have alleged that the Sherwood furnace at the ARBED plant did not function well and may have suffered a major failure, described in the letter as a "meltdown". It is noted that no such occurrence was reported in the report about the ARBED trials, which was prepared by ARBED engineers (file 52-Pro.5, attachment).

The conclusions to be drawn from the ARBED trials are:

(1) The Wooding furnace functioned satisfactorily as a slag melter only (and not to smelt chromite) at a rate of 4 tonnes per hour; this is on a scale close to that proposed for the Sherwood ferrochromium plant (nominally 5 tonnes/hr.).

(2) The construction and operation of the furnace at ARBED would appear to provide useful data for the design of a furnace to produce high carbon ferrochromium, using the same principles.

(3) As the ARBED furnace was not used to smelt chromite to produce ferrochromium, there is a lack of hard data on the emissions and, importantly, the particulate matter emitted. This has been a major concern throughout this review.

Metallurgical experts retained by Sherwood, by the Panel, and on behalf of intervenors all agree that there is no intrinsic reason why the process should not work, in spite of the fact that pilot plant tests at ARBED were limited to melting tests. (file 349-Pan/Ex.21; 364-Pan/Ex.29). Furthermore, there appears to be general agreement among the experts that the reduction conditions are such that hexavelant chromium cannot form within the smelting furnace and will not be present in the gases as they leave the furnace (Fruehan: Transcript, pp.103-104; Peters: file 320-Pan/Ex.19, p.8).

Despite the positive aspects of the design of this process, the concern remains that, as an integrated production system, this is a new design, not yet operated on an industrial scale.

Consequently, there are some remaining areas of uncertainty. First, the amount, composition and particle size distribution of the furnace dust remain uncertain. Second, there is the possibility that a small quantity of Chromium VI may be produced in the refiner off-gases if there is any excess oxygen in the refining vessel after decarburization. While this may be largely trapped together with alkalis in the steam ejector sludge, some is likely to continue in the waste gas stream (file 349-Pan/Ex.21). The frequent monitoring of the off-gases analysis is therefore essential. Third, the time required to fully commission the operation and achieve production capacity and quality remains

speculative and, based on experiences elsewhere with other metallurgical plants, may be longer than anticipated.

Conclusions and Recommendation

The panel concludes that the smelting and refining processes, as designed, are feasible. However, it is noted that the particular combination of technologies has not been employed before, and hence this plant will have some of the developmental characteristics of a pilot plant. Therefore the commissioning process may be longer than anticipated by the proponent.

It is observed that the carbon monoxide content of the smelter off-gases raises the possibility of explosion and fire hazard, and such ignition would be capable of causing the formation of chromium VI.

The Panel recommends that, due to the untested nature of this plant and the remaining uncertainties, it is appropriate to apply a "worst case scenario" approach to its environmental assessment and any permits that might be issued for this project.

2.4 SLAG HANDLING AND PROCESSING

Slag production from the primary melter is estimated to be 7347 kg/hr., which is equivalent to 1469 kg/tonne of low carbon ferrochromium. It is proposed that this slag be utilized as the raw material for production of mineral fibre (Sherglas). The Sherglas production rate proposed is 13,591 kg/hr., equivalent to 2,718 kg/tonne of low carbon ferrochromium produced by the plant, although the production rate is conditional on the level of market demand.

It appears to be unrealistic to expect that the ferrochromium production process and the Sherglas production process would operate simultaneously, such that no slag accumulates. If market conditions are not favourable for the conversion of all slag to Sherglas, then other arrangements for temporary or permanent disposal of the slag must be made. Sherwood proposes to cast slag into vitrified blocks for sale, landfill or later re-melting. The claim is that such material will be inert and therefore acceptable as landfill, either on-site or at other sites. To allay public concerns regarding the possibilities of leaching, Sherwood proposes to conduct leachate tests on experimentally produced material, and to make the results available.

2.5 MINERAL FIBRE PRODUCTION

"Sherglas is a glass filament which is a replacement for asbestos in plastic reinforcement, for paint, paper and many other products" (EIS Addendum, file 335-Pro.33, p.217).

The actual fiberizing process is an established one, currently operating commercially in Sweden (Transcripts, pp.1186-1223). The Swedish product, known as "Inorphil", is made from rock (diabase and dolomite) which are melted with coke in a cupola (an open style of furnace). In this process, 50% of the material is rejected and cannot be recycled. In the Sherwood project, due to the use of an electric melter, all unusable output can be recycled to the process. Testimony was given by Mr. W. Hartung, whose company produces "Inorphil" at Laxa Bruk, that although his company had no experience with melted slag from a ferrochromium smelter, he could foresee no technical difficulty, provided some adjustments to composition were made.

These composition adjustments (lime, silica and alumina) would be made in the Sherglas melter, a spherical furnace of similar design to the smelting furnace. Moreover, as indicated by Mr. Hartung, magnesia content should not exceed 14%. Although he did not offer a technical opinion, he said that he had not detected hydrogen sulphide formation in his process. In his view, the presence of a small percentage of chromium (as chromite) would not pose a technical problem.

At the Sherwood plant, once the slag is melted, the molten material would be spun in a water bath. The yield of fibre is estimated to be 50%, with the other 50% being recycled, after drying, back to the melter. The fibre would be dried and bagged for shipment. The net yield of Sherglas, assuming the plant is in full operation, is estimated to be 13,591 kg hr^{-1}.

The use of a water bath to receive and cool the spun fibres necessitates a treatment system such that this water may be reused repeatedly without being discharged to the environment. Condensed water is also collected, filtered and reused in the process.

Off-gases from the Sherglas melter, containing principally carbon monoxide, are to be sent to the waste heat economizer, where they would combine with gases from smelting and refining. Final cleaning would therefore be carried out in No.1 baghouse. Dust from the fiberizing operation and from the fibre and recycled "shot" would be collected in No.2 baghouse.

The original proposal from Sherwood included the production of mineral fibre from the slag. The proponent claimed that this would mean that the slag of the smelting operation would not accumulate at the Sherwood plant. There was much controversy and examination of this during this review. The material balances and flow sheets provided by the proponent are based on all the slag being converted into Sherglas mineral fibre. The hourly rate of production (13,591 kg/hr^{-1}.) is equivalent to an annual rate of about 81,500 tonnes.

During the hearings, it became clear that no firm contracts were in place for this product. In the proponent's Fifth Supplemental Submission (file 173-Pro.15), some information was provided. In that document, Sherwood estimated a potential North American market for this mineral fibre of 400,000 tonnes per year and this could rise to 800,000 tonnes per year by the end of the decade. It was also stated in that document that Sherwood had plans to bring a mineral fibre plant into production in eastern Canada in late 1991. Its initial capacity would be 20,000 tonnes per year.

As no evidence was provided in pre-hearing documents to support these projections, the Panel raised questions concerning the market potential at the hearings. The proponent's witness, Mr. W. Hartung, stated at the hearings that he believed the North American market could be about 400,000 tonnes per year.

Finally, at the hearings, the proponent indicated that this portion of the plant would not be built initially (Transcript, p.2645). The proponent stated that previously unforeseen costs (specifically for the environmental assessment process and additional costs of $2-3 million for hydroelectric equipment) have necessitated the trimming of this portion of the plant from Sherwood's capital budget (Transcript, pp.2646-7). At this point, it was also stated by the proponent that it would be necessary to store the slag until it could either be converted to mineral fibre at a later time or used as a fill material, a use that would require that the material was shown not to be leachable under natural conditions (Transcript, pp.2645-6).

This change of plans strongly affects several of the issues upon which this review focuses, including economic benefit, employment potential, water balance, and the production and handling of wastes. Notably, in terms of employment, the absence of the Sherglas operation would reduce jobs to 130 (Transcript, p.2643). In terms of water balance, the absence of the fiberizing plant could cause the remainder of the operation to produce excess process water, which would have to be dealt with appropriately.

Conclusions

It is the view of this Panel that the production of Sherglas is a technically feasible proposal. The uncertainty lies in the marketplace; the Panel has not been provided with convincing evidence regarding the market for this product. Therefore, the Panel is of the view that, if this plant is to be permitted, the assumption should be made that slag will accumulate.

Notwithstanding the feasibility of producing this mineral fibre product, it is recognized that it may have to tested and approved by an appropriate government authority, depending upon the product use. Close scrutiny may be paid by such authorities due to the production of the fibre from a ferrochromium slag.

The Panel is disconcerted by the proponent's late admission that slag would be stored, and that the fiberizing plant would not be operating from the outset. This change of plans during the course of the review makes the assessment of this proposal all the more difficult.

2.6 ANCILLARY OPERATIONS

Ancillary operations are those that do not necessarily play a direct part in the production of ferrochromium, slag or mineral fibre. They are, however, essential components of the facilities, contributing to energy conservation (eg. the CO boiler) and to capture and cleaning of emissions and effluents.

2.6.1 Dust Collection and Disposal

There are three sources of dust: dust from handling and preparing raw materials, dust from the furnaces, and dust from the fiberizing plant. The principal means of collecting these dusts are two baghouse installations. Baghouses are commonly used in the metallurgical industry and are particularly efficient at trapping sub-micron dust particles, provided they are properly designed, operated and maintained.

Furnace Dust

The first baghouse installation contains two baghouses (Nos. 1A and 1B), which are in series. Each one, when operating singly, is capable of cleaning all the furnace gases.

Off-gases originate in the smelter, the refiner and the Sherglas melter. The quantity and composition of these gases, after considerable revision during this review, are given in Table 4-10A of the Seventh Supplemental Submission (file 544-Pro.91). The quantity of dust entering the No.1 Baghouse is estimated to be 46.8 kg per hour and the amount released to the atmosphere is estimated at 84.6 grams per hour.

The refiner gas also passes through the baghouse but much of its dust is scrubbed out in the steam ejector and the waste heat boiler. The cleaned gas, containing 88% carbon monoxide, is burnt in a boiler to produce steam that is then used in the dryer and the steam ejector.

It is the proponent's position that, in the event of complete failure of the baghouse collection system, the design of the plant allows relatively prompt shutdown with no adverse effect on the metallurgical process.

Fugitive Dust

Fugitive dust is collected at the second installation, which also has two baghouses (Nos.2A and 2B). These are in parallel, rather than in series. Each is capable of handling the total gas flow.

Fugitive dust losses and emissions stem from raw materials handling and storage, smelter charging and tapping, refiner charging and tapping, and Sherglas charging, tapping, fiberizing and drying. Such emissions are more difficult to estimate than those from the process directly, since they are based on engineering estimates and will be strongly influenced by plant design considerations, as well as by operating and maintenance practices. In practice, only 50-60% of such dust is captured for treatment at the baghouses.

For instance, raw material handling losses are assumed to be 0.1% of raw material requirements (i.e. 16.89 kg per hr.). This figure is commonly used in engineering estimates but it is recognized as only an estimate for the purpose of plant design.

On the basis of estimates provided by Sherwood in the EIS Addendum, baghouse No.2 will handle 56.9 kg per hr., with an efficiency of 99.7%. The projected amount of dust leaving this baghouse is 170 grams/hr.

Dust Recycling

Dust collected in the baghouses, slightly more than 100 kg per hr., is to be recycled to raw material processing. From time to time, as trace elements accumulate, dust will have to be removed from the system and handled as "special waste" in accordance with provincial regulations. This procedure is in the proponent's interest with respect to maintaining product quality. Sherwood has stated that the recycling of dust from the baghouses will be regularly monitored. (file 335-Pro.33, pp.4-20 to 4-22 and file 544-Pro.91, pp.5-13).

Conclusion

Given the nature and estimated size distribution of the dust to be removed, a baghouse is an appropriate choice for collection of dust from the furnace gases and fugitive emissions.

Due to the accumulation of trace elements (such as zinc and arsenic, among others) in the recycled dust, it will be necessary for the proponent to periodically dispose of this dust, which would be

designated as a "Special Waste" by the Ministry of Environment, and deal with it according to specifications provided that Ministry.

2.6.2 Waste Heat Recovery

Waste heat is recovered from the smelter and the Sherglas melter gases in the waste heat recovery boiler, which cools the gases from about 1700°C to 200°C prior to entering the No.1 baghouse. Refiner gas already cooled in the steam ejector also passes through the heat recovery system. A small amount of steam is produced. The system also precipitates some of the dust at the bottom of the boiler and condenses most of the alkalis (sodium and potassium), as well as probably zinc and arsenic. The full list of steam ejector contaminants, as presented in Sherwood's Seventh Supplemental Submission, is:

	grams/hour
TSS	15,000
TDS	852
Al	180
Sb	19
As	13.7
Cd	2.7
Cr^{6+}	30.0
Cu	13.7
Pb	20
Hg	0.002
Ni	0.14
V	1.6
Zn	4.5

(file 544-Pro.91, p.34)

The exit gases are burnt under controlled conditions to yield nearly 90% of the total steam produced. The boiler design proposed will convert any sulphur to sulphur dioxide and produce only low levels of NOx, 50 mg per Nm^3 when corrected to 12% CO_2. Propane (LPG) will be used as a start-up fuel or if insufficient carbon monoxide is available.

Conclusion

The sulphur content of the propane used to fire the boiler will not significantly increase the total SO_2 emission from the plant.

2.6.3 Carbon Monoxide Combustion

The cooled and cleaned gases exiting the No.1 baghouse installation are rich in carbon monoxide (about 88% by weight). The theoretical rate of gas flow is 5500 kg per hour, equivalent to 4280 m^3 per hour at standard temperature and pressure. The emission of this much carbon monoxide would be unacceptable and wasteful. Therefore, the gas is burnt with combustion air in a boiler to produce steam, which is then used in the steam ejector system and for drying raw materials. NOx formation in this combustion process can be controlled by controlling the flow of combustion air, the flame temperature, by using staged combustion or by flue gas recirculation (File 544-Pro.91, flow sheet E4280G). No control of sulphur dioxide is proposed; there is a reliance on acquiring raw materials (particularly the anthracite) that are low in sulphur. No control of NOx is included, though a NOx reducer was originally proposed by Sherwood (file 52-Pro.5). It was eliminated from consideration but not as a result of a BACT analysis of the control technology.

Waste gases from the carbon monoxide boiler are estimated to be 18,600 kg per hour, equivalent to 12,500 m^3 per hour at STP. These gases are mixed with the exhaust from the No.2 baghouse and then vented to the atmosphere via the stack. Total undiluted gases sent to the stack are estimated by Sherwood to be 29,600 kg per hour, or 21,100 m^3 per hour at standard temperature and pressure (STP).

A flare stack is interposed between the No.1 baghouse and the inlet to the carbon monoxide combustion chamber. This would be used only in emergency conditions: for example, if the carbon monoxide burner failed to function. Sherwood claims that it would operate for a short time only (until the plant could be shut down). Dr. Stewart testified that the flare stack might be engaged for 1% of the operating time of the plant (Transcript, p.999).

The design also makes provision for bypassing the steam generator if steam is not required by the plant. In this case, waste gases from the boiler (combustion of carbon monoxide) would go directly to the stack. (File 544-Pro.91, flow sheet E4280G).

Conclusions and Recommendation

The Panel concludes that the boiler installation should operate as designed. Performance is expected to be guaranteed by the boiler manufacturer.

The Panel recommends that emissions from the flare stack must be included in the permit levels for total emissions, expressed in grams per hour, from this plant. These combined emissions should not exceed the permitted total mass rate.

2.6.4 Steam Utilization

The major use for the steam produced is to operate the steam ejector vacuum system which provides the vacuum for the VAOD refiner. The ejector is also a gas cooling device which converts steam to water in a non-contact condenser.

The other use for steam is to dry raw materials (chromite, anthracite, lime and silica) and Sherglas fibre.

According to Sherwood's calculation, there is a surplus of waste heat available to meet the steam requirements of the process. It is anticipated that "scale" will be deposited within the steam ejector, necessitating periodic cleaning.

Recommendation

It is recommended that any water used to remove "scale" from the steam ejector should be handled as contaminated process water.

2.6.5 Storm and Process Water

The water treatment flowsheet was introduced as Figure 2-9 in the EIS Addendum (file 335-Pro.33), and was subsequently revised during the October public hearings (file 386-Pro.51). A later "Process Water and Steam Flowsheet" was prepared and submitted by Sherwood as Drawing No.D3586 (file 544-Pro.91).

Surface (storm) water runoff is collected in containment basins from which make-up water is taken. Storm water runoff is checked before discharge to the ocean outfall. If treatment is required, it will be passed through the process water treatment plant.

The three containment basins shown in Drawing No.3586, with a total volume of 800 m^3, would provide capacity for 2.65 days duration of the daily average of typical December rainfall and only 1.52 days in a wet month. During periods of exceptionally heavy rainfall, the capacity of the basins would be reached more quickly. This issue was raised by Mr. W. Lemmon (file 544-PS.236). The proponent's view is that in such circumstances, contaminants would be flushed to the basins in the early part of the storm, that subsequent run-off would be likely to be clean water, and therefore the surplus run-off is unlikely to require treatment (Transcript, p.3194). The proponent admitted during the final hearing that the size of the holding basins required more detailed design.

Apart from the conceptual feasibility of the proposed handling of storm water, it has proven difficult to reconcile the numerical data provided by the proponent. The information provided in the EIS, the EIS Addendum, the Seventh Supplemental Submission as well as testimony at the hearings has been inconsistent and contradictory. As a result, it has been impossible to calculate a plant water balance with any confidence. No water consumption figure has been given for the fiberizing process, which, as is now known, will not be in operation for at least two years.

Process water is water used internally within the plant for direct cooling purposes. In the system proposed, all process water is contained in a closed circuit, with none being discharged to the environment as effluent. The proponent maintains that evaporative losses require some make-up which will come from storm water runoff and from the municipal water system (up to 7 litres per year).

While no water consumption data has been given with regard to the Sherglas plant, evidence presented by Mr. Lemmon (file 544-PS.236) indicates that without this fiberizing operation, there would be an excess of water in the process, due to the water content of the raw materials. This would imply a possibility that process water could be continuously discharged, instead of remaining in a closed circuit as proposed.

The main source of contamination in the process derives from the steam ejector, which acts as a scrubber for the refiner off-gases. Most of the dust in this gas, as well as heavy metals and alkalis, will be collected in the condensate. This condensate and make-up water, after adjustments to the acidity (pH) level, are passed through a lamella clarifier which removes suspended solids and precipitated heavy metals. The solids are filtered and either recycled to the process or, if unsuitable, stored in steel drums to await appropriate disposal.

Overflow from the clarifier and filtrate are held in the process water tank from which after further pH adjustment, water is passed through activated carbon columns to remove any Chromium VI and organic carbon which may be present. Dissolved gases (O_2, CO, CO_2, and N_2) are removed in a de-aerator. A de-ionizing step provides the final stage in providing high quality feedwater for the boiler and cooling requirements.

The handling of process water also includes consideration of the backflush of the carbon cartridges (not addressed by the proponent), the solids from the heat recovery system, and the solids from the boiler and steam ejector. It is understood that carbon cartridges are normally recycled by backflushing, although the proponent does not address this subject; discarding them incurs great expense.

Conclusions and Recommendations

Insofar as the Panel can judge, it appears that the storm water and process water treatment scheme advanced by the proponent is technically possible and makes use of processes and equipment currently in industrial use for water treatment. However no specific installations (or costing) of pollution control equipment, especially with regard to the carbon cartridge system, is given.

Insufficient evidence has been given that there has been due consideration to the frequency, duration and volume of heavy rainfall in the Port Hardy area. This raises concerns about the adequacy of storage facilities.

The Panel recommends that the data on which the plant is designed, including the design criteria, equipment selection and sizing, be fully resubmitted by the Proponent and reviewed and approved by the B.C. Ministry of Environment. This review must take into account:

(1) adequate rainwater and process water storage for flood conditions.

(2) plant sizing to treat surplus water in times of excessive rainfall.

(3) contingency plans in the event storage and plant capacity are inadequate for short term emergencies.

The Panel recommends that containment basins should be of sufficient volume to store all excess process water and excess storm water run-off, with provision of additional storage capacity, such as a lagoon, to handle heavy rainfall periods. The plant must be zero discharge as proposed.

While the capacity of the design of the waste water treatment are understood, a doubt exists with regard to whether the process units will be net consumers of water (as claimed by the proponent) or at times net producers of water (as suggested by Lemmon).

2.6.6 Seawater Exchange Cooling System

The plant is designed to utilize seawater for cooling purposes. As there will be no direct contact with the smelting process or raw materials, this water will be returned to Hardy Bay with no additions of process substances. The fact that the process water will be under negative pressure means that under no circumstances could process water enter the seawater exchange system.

From intake to outlet, there will be an increase in temperature of 5°C; this matter is dealt with in Section 3 below.

Treated waste water from the on-site sewage treatment plant will be added to the discharge of coolant seawater.

Conclusions

This proposed cooling system is determined to be feasible and practical at this site.

It is not possible for the seawater exchange system to become contaminated with process water or any of its constituents.

Considering the relatively small volume and the organic nature of this waste stream, and assuming that the sewage treatment system would comply with current regulatory standards, this method of discharge is acceptable.

3.0 IMPACTS UPON THE RECEIVING ENVIRONMENT

The environmental assessment of the Sherwood project is, due to nature of the subject material and the evidence before the Panel, extremely technical. Much of the text involves technical analysis of the available information. For the benefit of non-technical readers, summaries and overviews have been provided at key points. For technically-inclined readers, further details for some sections are provided in Appendices G, H, I, J , K and M, located at the back of this report. Considerable effort has been made to standardize as many as possible of the measurement units used. A glossary, also located at the back the report, may be consulted for quick definitions of the abbreviations used throughout.

The following "General Overview" provides preliminary insight into the subjects of greatest significance in this review. **Section 3.2**, supported by **Appendix G**, examines the issue of chromium toxicity in the context of public health. **Section 3.3**, supported by **Appendices H, I, and J**, assesses the impacts of air emissions from the plant. In **Section 3.4**, supported by **Appendices J, K and M** impacts upon the aquatic environment are examined. **Section 3.5** assesses impacts to the terrestrial environment. Finally, **Section 3.6** provides overall conclusions, derived from the preceding analyses and recommendations.

3.1 GENERAL OVERVIEW

The assessment of the impacts of the Sherwood proposal on the receiving environment must be approached by first considering the scale of the installation, and consequently the range of the significant impacts that must be reasonably taken into account.

Physically, the plant requires "16.1 hectares (40 acres) of relatively level land" (EIS Addendum, p.2-1) and involves the production of 30,000 tonnes of finished product (low carbon ferrochromium) per annum. Concurrently, slag (44,082 tonnes), heated seawater (dissipated by the seawater heat exchange system) and carbon dioxide (45,800 tonnes) are the major byproducts. For comparison,

it is notable that even a relatively small Kraft pulp mill or integrated iron and steel smelter operation would target a minimum of 1 million tonnes of product per year.

As earlier discussed in this report, the slag may be further processed into Sherglas; if so, there would be little accumulation of slag and this would not be an important issue.

As a result of the relative scale of the Sherwood proposal, impacts on the terrestrial environment through land surface alteration or through the disposal of wastes are minor relative to major projects such as power plants.

Similarly, plant design is now such that loss of foreshore or marine habitats through construction is of reduced significance and therefore this physical impact is not a critical factor in the overall assessment of this project. In this regard, the relocation of the material storage area to an upland location was an important change in design. The cumulative effect of further development on Hardy Bay from an environmental impact perspective is beyond the terms of reference of this Panel.

This plant would have only localized physical impacts on species habitats, particularly in comparison to other kinds and scales of industrial development. This is not to say that such localized habitat impact is acceptable; indeed the Department of Fisheries and Oceans, native groups, and the United Fishermen's and Allied Workers' Union, and others made representations to this Panel regarding the incremental loss of "localized" marine habitats on Hardy Bay. The concern is that the cumulative effect of such relatively minor impacts, based on the experience elsewhere, could be a significant change in the abundance and quality of the marine ecosystem in this area. To this end, the Department of Fisheries and Oceans espouses a "no net loss" principle. Even so, the physical impacts to the marine environment appear to constitute a relatively minor, localized issue for this review.

Notwithstanding the above comments regarding plant scale and physical impact, there are two physical effects that have warranted closer scrutiny in this review. The first of these is the physical impact to seabed ecology near the docking area due to spillage of ore and other raw materials offloaded at the dock. The second is the potential thermal effect of discharging heated seawater into Hardy Bay over an extended period. These marine issues are dealt with in **Section 3.4.**

The potential impact on the environment, and the focus of public concern in the Sherwood proposal, is the identity and toxic effects of the air emissions, effluent discharge (if any), and potential leachate from raw materials or land filled wastes into surface or ground water. In particular, concern focuses around chromium. The chemical state, bioavailability, and hence the public health and environmental danger of chromium has dominated the evidence presented to the Panel. Other potentially harmful elements and compounds - zinc, arsenic, mercury and the acid gases NOx and SOx (principally nitrogen dioxide and sulphur dioxide) must also be considered. From consideration of the process and the raw materials, the trace element contaminants are likely to be of low significance in comparison to the chromium emissions. Chromium remains the principal concern.

In conclusion, the significant impacts of the Sherwood smelter, both on ecosystems (populations, diversity) and on human health stem from the amounts, bioavailability and adverse effects of low levels of chemical contaminants. Both chronic (long term) and acute (short term) effects have been cited in evidence. In this chapter, the potential impacts of toxic constituents in the effluents and emissions will be considered from the point of view of the dispersion and potential for accumulation (including bioaccumulation) that could adversely effect the environment and the residents of the Port Hardy area.

3.2 CHROMIUM / PUBLIC HEALTH ASSESSMENT

Public health concerns presented by the Sherwood facility focus upon trace toxic elemental contamination of air (respirable material), water supply and land (food supply). While the air emissions include lead, mercury and arsenic constituents -- dealt with separately in Section 3.3 (Air Quality) below -- the chromium hazard has dominated both public concern and the evidence on the impact on human health. In this section, a brief summary of the main aspects of the chromium issue is provided based on the evidence before the Panel. Appendix G is a technical discussion of chromium toxicity; readers may find this to be useful background information.

3.2.1 Current Regulations and Standards

Occupational Health and Safety Considerations

In evidence provided to the Panel by a number of witnesses, it became apparent to the Panel that the exposure levels permitted for workers were traditionally much higher than ambient air objectives. For example, in British Columbia the practice is to follow the 1990-1991 Threshold Limit Values of the American Conference of Governmental and Industrial Hygienists (ACGIH). The adopted values (file 406-Govt.42) are 0.05 mg m^{-3} for Chromite ore processing (chromate) for chromium.

The latter value has caused much confusion in the designation of carcinogenicity of chromite ore by ACGIH in some references, when in fact chromite ore processing was intended as the subject. The misconception has been transferred to a number of secondary references, including The Condensed Chemical Dictionary (Van Nostrand Reinhold publishers, 1981, see file 523-PS.220).

Much of the testimony of Dr. Bidstrup for the proponent was based on corresponding United Kingdom Health and Safety Executive, 1989 values, namely 0.5 mg m^{-3} for Chromium and Chromium III compounds, and 0.05 mg m^{-3} (under review) for Chromium VI compounds. Such values contrast sharply with the Lowest Observable Affects Level (LOAEL) of 0.002 mg m^{-3} for Chromium VI most recently presented by the United States EPA (file 571-Pro.98). It should be noted that concern over occupational exposure is increasing in the United States EPA analyses. In

the document Noncarcinogenic Effects of Chromium: Update to Health Assessment Document (file 425-BI.38), page 6-20, it is concluded that

> "Recent data ... support earlier findings ... that in occupational settings air concentrations above 0.002 mg m^{-3} of CrVI as chromic acid are highly irritating to the nasal mucosa and can induce morphological changes".

Further, the suggestion is made that the

> "...lower the acceptable level to 0.01 ug* Cr(VI) m^{-3}. Since it is very difficult to determine small amounts of chromium species in air, a level of 0.05 ug of total chromium per m^3 (cubic metre) is recommended."

The subsequent RfC value (Reference Concentration for Chronic Inhalation Exposure) of 0.002 ug* m^{-3} clearly reflects the increasing concern over both ambient air and work place exposure.

In the opinion of this Panel, the practice of using Threshold Limit Values (TLV) directly, rather than in conjunction with other data sources, needs to be reviewed. Persons spending a significant fraction of their lifetime in affected workplaces require a close monitoring of the overall doses of toxic materials being received relative to the population at large.

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* One "ug" (phonetically, "mu gram") refers to one microgram, which is 1 millionth of a gram.

Ambient Air Standards for Chromium

A number of ambient air standards have been cited in evidence by the proponent, largely in contention of the total chromium value of 0.05 ug Nm^{-3} (i.e. 0.05 micrograms per normal cubic meter), long established by the Province of British Columbia, Ministry of Environment, as published in the document Pollution Control Objectives for the Mining, Smelting and Related Industries of British Columbia (file 405-Govt.41).

Given that the British Columbia value is a 24 hour average concentration, it corresponds approximately to a yearly average of 0.005 ug Nm^{-3}. This value, alternately expressed as 5 ng Nm^{-3} (1 ng = 1 nanogram = 0.001 ug) has been analyzed by Dr. R. Caton, in evidence submitted to the Panel, as representing less than a one in a million risk for cancer in a 70 year lifetime, provided the CrVI content of the chromium was about one percent (file 420-Pan/Ex.38). Interestingly, Dr. Caton quoted the World Health Organization risk for 0.001 ug m^{-3} Chromium VI as one in 400,000 compared to the United States' EPA's calculation of one in 120,000. This world body takes a similar approach to the cancer risk of CrVI, on which the 0.00008 ug m^{-3} ambient standard proposal is based.

The proposed Ontario standard of 1.5 ug m^{-3} for "total chromium in free and combined form per cubic meter of air", as contained in the projected revisions to the Ontario General Regulation 308 - Air Pollution, requires comment. First, careful examination of the --regulation reveals that the Ontario objective is to achieve an air modelling result that gives 30% of the value as a maximum level -- a so-called "type A result". Any higher values (type B results) must be reconsidered so that all area sources combined do not exceed the 1.5 ug m^{-3} value. The 30% value would be 0.45 ug m^{-3}. As a 24 hour value, it would correspond (approximately) to 0.045 ug m^{-3} on a yearly basis.

The proponent has cited the proposed United States "Clean Air Act" values which the State of South Carolina has adopted (August 9, 1990) (file 421-Pro.67). The maximum allowable concentration at the property line for Chromium VI compounds is given as 2.50 ug m^{-3}. One is struck by the contrast between the United States EPA RfC value of 0.002 ug m^{-3} and this latter suggestion. This contrast is resolved in the realization that the one hour (or spot maximum) values can be fifty times yearly averages, for example as revealed by the ambient air calculations of the proponent (file 544-Pro.91, p.19).

Further data provided by the proponent noted the lack of any standard for the operations in the Republic of South Africa, and a number of anecdotal references (file 536-Pro.70) from correspondence with an American law firm purported to be familiar with the application of standards in the United States. That party cites Maine as regulating ambient air total chromium at 0.3 ug m^{-3}, although over a 24 hour period. Apparently, the intention by the State of Maine is to proceed to 0.001 ug m^{-3} of chromium VI alone, again presumably over a 24 hour averaging period. The correspondence (file 536-Pro.70) cites Connecticut as requiring emission limits for chromium compounds (the metal, chromite ore processing), all in the range of 0.5 - 50 ug m^{-3}, an impressively strict standard not further quoted by the proponent in their later Seventh Supplemental Submission (file 544-Pro.91).

A fluid situation exists in the regulatory arena, gravitating toward more stringent regulation of Chromium VI emissions and concomitantly, toward the regulation of total Chromium emissions at lowering levels. The latter trend is based on the inability to accurately speciate the element into CrVI and CrIII forms at low concentrations, and as well, to the uncertainty associated with the dynamic interconversion by oxidation and reduction of the two forms. The Regulatory actions are virtually entirely based on human health rather than ecosystems. Significantly, no agency, including the EPA, has yet made a final determination on the extent of the human toxicity of Chromium III.

3.2.2 Chromium Emissions in the Environment

Bioavailability of chromium in the emitted particulate and effluent was an issue that provided sharply conflicting evidence to the Panel. First, Dr. Peters (UBC professor of metallurgy and consultant to the Panel) and Dr. Hartford (consultant to Sherwood) were in agreement that chromium in chromite ore would only be mobilized extremely slowly in natural systems, if at all, either through biological action or chemical solubilization. In Dr. Peters view, spillage offshore would remain on the bottom as inert material, not providing significant chromium to the marine ecosystem. Dr. Hartford also contended, both in evidence to the Panel and in subsequent correspondence (file 494-Pro.83), that Chromium III compounds could be divided into soluble salts, reactive hydrated oxides, and inert refractory oxides. The latter would likely be formed in the high temperature conditions of the waste heat boiler. He suggested that this latter material, at any particle size, would be insoluble and relatively unreactive both chemically, toward oxidizing agents, and biologically.

In contrast, Dr. Jerome Nriagu responded by suggesting the inert character of the chromium oxide cited above could be largely restricted to the mineral form, chromite. Even then, as a geochemist, Dr. Nriagu suggested that the absence of free chromite ore in areas where chromium is present in soils, such as the Canadian Shield, could even indicate mobilization (solubilization) of chromite. Based on small particle size, and the less homogeneous chemical composition of the material, he was unwilling to rule out solubilization of chromium in particulate emitted from the Sherwood process.

Dr. Goyette of Environment Canada,in assessing the toxic effects of mineral spillage at harbour facilities, has concluded that metal concentrations from such materials become distributed throughout sediments, and are often observed to exhibit effects (some toxic) on the benthic organisms. Dr. Peter Chapman, consultant to the Panel, also advised that protocols for assessing possible elemental effects on sediment health are at present based on overall concentrations of metals etc., independent of speciation. Such evidence tends to suggest caution in segregating some chemical compounds as being a priori unavailable in the ecosystem.

Apart from bioavailability through solubility and/or complexation by chelating agents, Dr. Nriagu emphasized the importance of the oxidation of chromium in the emitted particulate by hydrogen

peroxide. Other oxidizing agents (for example, oxygen itself and manganese dioxide) are known to convert CrIII to CrVI, both in soils (MnO_2) and in seawater.

A recent publication by M. Pettine and F.J. Millero, 1990 (file 547-Pro.92, Attachment 1) was cited by Dr. Nriagu and thoroughly presented in evidence as an important new contribution. He concluded that this laboratory study of the oxidation of Chromium III by hydrogen peroxide in the pH range 7.0 - 10.0 revealed rates of reaction some 20 times faster than oxygen, reducing the projected half life (at a seawater hydrogen peroxide concentration of 18 ug per litre) to 24 days, as opposed to the 500 day half life for oxygen at the concentrations found in seawater. The study predicts an equilibrium concentration of Chromium VI of 19 parts per trillion at the surface, comparing favourably with the established concentration of 5 parts per trillion of CrVI at the surface in the deep sea.

Pointing out that radical chain reactions can create hydrogen peroxide in the atmosphere and hence in aerosols, Dr. Nriagu contended that particles emitted from the stack could undergo enhancement of their Chromium VI concentration both while airborne and while in the surface zone (photic) of surrounding marine and fresh water bodies. It should be pointed out (file 544-Pro.91, p.25) that 60% of the particulate will be less than one micron (one millionth of a meter) in diameter. In the view of Dr. Nriagu, this particulate would be especially susceptible to oxidation.

Examination of the Pettine and Millero paper does, however, reveal a slower rate of oxidation for "aged" chromium III solutions. These are solutions where a significant formation of hydrated oxides of Chromium have formed. The rate of oxidation of suspended particulates, that might be in the view of Dr. Hartford, largely in an inert oxide form, was not undertaken in the Pettine and Millero studies. Unfortunately then, extrapolation of the results to either chromium oxide bearing particulate in solution, or to airborne particulate interacting with aerosols, remains speculative at this point. Nonetheless, the possibility of enhancement of CrVI concentration after emission has been raised.

The dynamic nature of oxidation-reduction processes must be emphasized. Chromium VI is easily reduced, particularly by phenols and carbohydrates that are found in inshore waters (rivers, estuaries, etc.). The Panel's records contain no evidence from examination of natural systems that suggests the hydrogen peroxide pathway (which has always existed) has been important enough to

create an excess concentration of Chromium VI in waters, such as those in the immediate Port Hardy area.

3.2.3 Chromium Emission Levels for Sherwood

In the event that the facility receives a technical affirmation, the terms of reference of the Panel include the setting of guidelines for emissions and effluents that would prove useful to the Ministry of Environment in developing Waste Management Permits.

The Panel recommends that in the public interest, hazardous substances such as chromium should be regulated so that no detectable effect on human health is created. This includes ensuring that the risk of additional cancer incidence is minimized to less than one in a million in accordance with standards adopted by a number of organizations internationally, including the U.S. EPA.

Accordingly, it is recommended that the ambient objective for Chromium VI should be the current EPA ambient level suggested by the proponent, an air concentration of 0.085 ng m^{-3}.*

The critical question though remains: What total chromium ambient concentration will best reflect a Chromium VI concentration in that range? What emission level (mass-rate) corresponds to that to that value?

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* An "ng" refers to a nanogram, which is one thousandths of a microgram, or one thousandths of a millionth of a gram.

In order to set such values, the Panel has considered two questions:

(1) Is the 5000:1 ratio of CrIII to CrVI in the particulate as it leaves the stack a reasonable value? Even if so, is the bioavailability of the remaining Chromium III likely to be negligible, as contended by the proponent, or significant?

(2) What is the reactivity of the Chromium in the particulate after it leaves the stack? The Panel has not been presented with complete expert consensus on this issue. The salient points of general agreement are summarized as:

(a) Chromium is naturally widely distributed throughout terrestrial, aquatic and marine environments, and in the biota of these ecosystems at low levels.

(b) Chromium, at low levels, is an essential element for human beings and certain other species.

(c) Chromium exists in dynamic equilibrium in the environment; a Chromium cycle is currently in place.

(d) Chromium cycles involve solubilization (as complexes and ionic forms) and an oxidation reduction equilibrium exists between Chromium VI and Chromium III.

(e) Natural oxidation to Chromium VI likely involves hydrogen peroxide, oxygen and manganese dioxide, among other oxidants, and may occur for CrIII-containing particulate in air and water.

(f) Reduction of CrVI to CrIII occurs in natural systems mediated by organic matter (phenols), bisulphites and other reductants.

(g) The inhalation (respiration) of Chromium as Chromium VI (chromates) has been shown to result in an increase in the risk of carcinoma.

The Panel is aware of the possibility of the post-emission conversion to Chromium VI, and of the remaining uncertainty of the Chromium VI content in the particulate.

Therefore, the Panel cannot accept the 5000:1 CrIII:CrVI ratio at the point of environmental impact. Such a ratio is a best case scenario, not a worst case. Protective factors must incorporated, in order to account for the untried nature of the primary smelter, as well as to allow for the possibility that new areas of scientific inquiry, suggested by Dr. Nriagu and others, could reveal much lower ratios once the chromium-bearing material has been exposed to the environment.

As a result, the ambient level of 0.002 ug m^{-3} for total chromium (with its implicit factor of 25, leading to the CrVI value of 0.08 ng/m^3) must be adopted.

It is recommended that the emission rate for total chromium be set at 2.0 mg Nm^{-3} (refer to Lemmon: file 393) and allowed only if the ambient levels set above are predicted to be achievable by the modelling studies. The corresponding mass rate is 41.7 g/h (grams per hour).

As it turns out, this total chromium value is relatively close to achievement in the proposals currently advanced by the proponent. If the 2.0 mg m^{-3} value were to be adopted, a one year maximum discharge for the site under consideration is calculated as 0.035 ug m^{-3} for a 34 metre stack, and 0.006 ug m^{-3} for a 60 metre stack. Much lower values -- in the order of 0.001 ug m^{-3} -- are predicted in the populated communities, sufficient to minimize individual risk to less than one in one million (assuming that CrVI is 4% of total chromium).

The Panel recommends that, wherever the plant is sited, the total chromium ambient value of 0.002 ug m^{-3}, based on the recent EPA RfC proposal, must be achieved, met or exceeded in air modelling analysis for all inhabited areas.

It is recommended that the current B.C. total chromium ambient standard of 0.05 ug Nm^{-3}, enforced on a yearly basis, not be exceeded at any point outside the perimeter of the plant.

Furthermore, it is recommended that the 0.05 ug/Nm^3 total chromium value should be regulated as achievable on an annual basis, and not the implied 24 hour in the B.C. Pollution Control Objectives. (file 405-Govt.41).

Furthermore, it is recommended that all ambient values should be regulated by specified time periods (hourly, 24 hour or yearly) in the B.C. Pollution Control Objectives.

3.3 AIR EMISSIONS ASSESSMENT

3.3.1 Air Quality Parameters

Significance of Air Emissions

Given the proponent's assertion that no direct (treated) process water will be discharged, air emissions are the principal projected route for entry of toxic or deleterious contaminants from the Sherwood plant into the environment. This conclusion is substantiated by the original permit application of Sherwood Metallurgical to the Waste Management Branch of the B.C. Ministry of Environment (January 5, 1990; file 11-Pro.2). This permit application specifies particulate, NOx and SOx discharge as follows:

Values in mg Nm^{-3}. Conditions: 20°C and 1 atm. pressure

	Particulate	NOx	SOx
Average	150	158	256
Maximum	200	256	413

Two baghouses in parallel, an electrostatic precipitator and "NOx by NOx" reducer were specified as the treatment. Production was to be 90 tonnes/day (2500 tonnes/year) or 278 days operation per year. A stack height of eight meters, commencing from a base elevation of 20 metres, was specified. From the stack, a flow velocity of 10.7 metres per second at a temperature of 80°C were specified as the emission conditions. Notably no permits for liquid contaminants were applied for, except 40 litres per day of "boiler purge" water, said to contain "some boiler scale" and "non-toxic" particulates. Maximum concentrations were said to occur twice per day for four hours. Finally the before-treatment values of NOx (2536 mg Nm^{-3}) and after-treatment values (256 mg Nm^{-3}) indicate significant effects of the reducer.

Request for "BACT" Analysis

Early in the review process, the Panel requested the proponent to provide a detailed emissions statement as part of its Environmental Impact Statement (EIS). It was also requested that criteria

of "Best Available Control Technology" (BACT) be used, with the advice that the following definition might be used:

> "Best Available Control Technology (BACT) means an emission limitation (including a visible emission standard) based on the maximum degree of reduction of each pollutant subject to regulation under the Waste Management Act which would be emitted from any proposed major stationary source or major modification, on a case by case basis taking into account energy, environmental and economic impacts and other costs that the Director determines is achievable through the application of production processes or available methods, systems and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each pollutant. In no event shall the application of Best Available Control Technology result in emissions of any pollutant which would exceed the Pollution Control Objectives Level A for The Forest Products Industry of British Columbia." (1977) (Ministry of Environment).

It was also suggested that:

> "The proponent can use an alternate definition of BACT. The above definition is based on the U.S. EPA BACT approach."

For emissions, the environmental impact and the level of contaminants that may be released (concentration and mass rate) are critically dependent on the dispersion of the released materials, requiring (1) meteorological evaluation, (2) air quality modelling, and hence (3) air quality impact. All of these requirements were outlined for the proponent in file 149.

Subsequently, the Panel received advice from Mr. Sagert (and input from consultants to the intervenors and from government ministries) that the dispersion modelling in the proponent's EIS did not allow impact on air quality to be ascertained with sufficient confidence (Sagert, file 231-Pan/Ex.6). Mr. Sagert further advised that "BACT does not appear to be addressed". The Panel then requested (July 9/90: file 304-Panel.36) that the BACT analysis be undertaken and included in an addendum to the EIS. On receipt of the proponent's "EIS Addendum" (file 335-Pro.33), further concern arose over the lack of formal treatment of the BACT concept. For example, a report of Dr. R. Caton (consultant to the intervenors) states:

> "The emission estimates in Table 4-10 (and associated predicted impacts in Table 5.2) ... do not refer explicitly to Best Available Control Technology (BACT)." (file 347-Pan/Ex.20, p.2)

The issue of BACT was further addressed during the hearings, in testimony by Mr. P. Sagert (Transcript, pp.1134-1186) and through the Ministry of Environment (Transcript, pp.1484-1496). The current BACT definition in use by the B.C. Ministry of Environment is as follows:

> "Currently available state-of-the-art control technology which is proven and has been successfully applied for at least one year in similar facilities in the Province or in other jurisdictions, and which is reasonably cost-effective as determined by the Ministry.
>
> The control technology includes process technology and equipment, raw materials, fuels and pollution control equipment or devices used to minimize waste generation."
> (W. Lemmon: file 415-Pan/Ex.34).

The above is essentially an abridged version of the definition supplied to the proponent in the original scoping instructions (file 149-Panel.8) for the EIS. (Refer to Appendix L for a description of the key steps in a BACT analysis, as supplied within file 149).

During the hearings period, and as a consequence of expert testimony and responses to questions from counsel and the Panel, the proponent was provided with two formal requests for further data: (1) "Request for Additional Information and Rationalization of Addendum EIS Report" (Oct.12/90: file 440-Panel.49); and (2) a letter to the Panel from Mr. Sagert "re. BACT evaluation" (Oct.15/90: file 461-Panel.50, Attachment).

Subsequently, a partial response to these two requests (as noted above) were forthcoming from the proponent in its "Seventh Supplemental Submission" (file 544-Pro.91). However, prior to the submission, as an understood condition for the convening of the final hearing session (December 1, 1990), the proponent agreed that further modelling of the air quality (i.e. the questions of stack height, dilution air and temperature) would be deferred, but would be subsequently addressed should the Panel recommend "approval in principle" of the project. (file 539-Pro.90).

In the "Seventh Supplemental Submission" (file 544) and in the proponent's final submission (Snow: file 559-Pro.95), the necessity of further consideration of BACT, and implicitly of further modelling appears to be much more qualified. For example:

> "Slavish adherence to EPA procedures is not necessarily the most appropriate solution to stack design and emission management for this plant." (file 544-Pro.91, p.1).
>
> "Sherwood's proposed permit emissions will comply with relevant emission standards, cause no significant adverse environmental effects and are based on BACT." (file 559-Pro.95, p.13) (Panel's emphasis).

> "Sherwood believes its proposal is BACT. We believe that Mr. Sagert is placing form before substance in a way that is not helpful to the Panel in conducting its environmental assessment. Mr. Sagert's principal reason for a BACT analysis seemed to be that the Ministry of Environment would follow EPA procedures and ask for a BACT analysis." (file 559-Pro.95, p.18).

It is informative to review the advice of Mr. Sagert to the Panel:

> "... if that decision in principle recommends that the project be allowed to proceed, the decision should be subject to the Proponent completing a more detailed BACT evaluation, air quality dispersion modelling evaluation and a risk analysis prior to the issuance of the air permit by the B.C. Ministry of Environment." (file 566-Pan/Ex.47, p.1).

and further:

> "The proponent appears to be about 25-33% of the way through a BACT process.
>
> The overall BACT level of progress appears consistent with Mr. Snow's (Davis & Co.) letter of October 29, 1990." (Sagert: Ibid. p.2).

In the aforementioned letter of Mr. Snow (file 539-Pro.90), the proponent seems to concede the need for further work on the evaluation of the air quality effects of stack heights of less than 60 meters.

In conclusion, the Panel's assessment of environmental impact in this report must be made in the context of the continuing lack of a complete and final resolution of the BACT analysis, with particular reference to air emissions. The Panel believes that the advice of its consultant, Mr. Sagert, remains prudent and well considered.

The Panel recommends that the proponent be required to complete further BACT analysis of air emissions, based on and including the items suggested in the correspondence from panel experts as contained in files 566-Pan/Ex.47 and 461-Panel.50.

It is further recommended that the Ministry of Environment should await the proponent's completion of this BACT analysis prior to the consideration of the issuance of permits.

3.3.2 Existing and Proposed Emission Standards

NOx, SOx and Particulates

Further to the initial suggestions of the proponent (outlined in sec. 3.1.1 above), the "Seventh Supplemental Submission" contains final revised projections of actual emissions quoted only as averages, expressed as both mass concentration (mg Nm^{-3}) and mass rate (grams per hour). (File 544-Pro.91, p.18, Table 5-2A). The same table proposes waste permit values in both units, and compares with the 1979 British Columbia objectives, and with values proposed by the expert consultant to the intervenors, Mr. W. Lemmon (file 393-Pan/Ex.31). The values are excerpted below for comparison for these three air contaminants, the only materials mentioned in the original waste permit application.

Refer to Table 3-A1 on the following page.

The proponent has repeatedly revised its emission figures. Particularly notable was the reduction in sulphur content of the gas stream due to a new calculation by Dr. Fruehan indicating capture of the sulphur in the slag phase. The change resulted in a revised "Emission Rates and Predicted (Ambient) Maxima" (Table 5.2 of the EIS Addendum, file 335-Pro.33), together with new basic "data" values as contained in a revised Table 4.10 of the EIS Addendum. The new tables appear as file 400-Pro.59 in the record.

In proceeding to Table 5.2A (Seventh Supplemental Submission), some additional changes occur. For example, the value of NOx (as NO_2) has changed from 1180 grams per hour to 2572 grams per hour without qualification. The Panel assumes the latter value is uncorrected (for CO_2 content), while the former reflects the approximate value of 50 mg Nm^{-3} that is projected for the carbon monoxide boiler, based on the 12% CO_2 reference standard.

TABLE 3-A1: COMPARISON OF EMISSION LEVELS

	Jan.1990 Permit Applic.	Dec.1990 Actual Suggested by Sherwood	B.C. 1979 Objective	Lemmon's Suggested Level	Proponents Suggested Level
Temperature	20°C	0°C	20°C	20°C	0°C(20°C)
SO_2 Conc. ($mg\ Nm^{-3}$)	256-413	51	714	200	190(177)
Mass rate ($g\ hr^{-1}$)	9,861 -15,908	1,070	---------	--------	4,000
NOx Conc. (as $NO_{2)}$	158-256	122	624	200	190(177)
Mass rate	6,086-9,861	2,572	---------	---------	4,000
Particulate Conc.	150-200	12	46.6	20	19 (17.7)
Mass rate	6,000-8,000	255	--------	--------	400
CO conc.	-------	37	--------	20; (70 = revised)	70 (65.2)
CO mass rate	-------	780	--------	--------	500

NOTES:

1. "Conc." refers to concentration in milligrams per normal cubic meter.
2. In the column "Proponent's Suggested Level", the figures in brackets have been calculated for the temperature of 20°C from the actual figures given for O°C.
3. The "Dec. 1990 Sherwood" values refer to a "combined stream", 21,079 $m^3\ h^{-1}$ at STP (0°C and 1atm), no dilution air.
4. NOx (Dec.1990 value) is apparently uncorrected for % CO_2 in gas.

Notwithstanding, the above permit levels suggested by the proponent seem to be comparable with emission guidelines of Canadian and North American agencies and these should be achieved, provided the performance of the carbon monoxide boiler and baghouse filters truly reflect BACT technology as suggested by the proponent. (Further discussion follows below on this matter).

Since mitigation actions, de-sulphurization or de-nitrification, are now both absent from the design, the Panel finds that compliance must rely exclusively on "source control" -- burner technology for NOx and low sulphur gas resulting from slag capture of most of the sulphur. In the first year of full operation, greater than 80% capacity, stack gas analysis will be an essential part of the start-up monitoring program.

The Panel can only make these generic observations since the proponent has not pursued a BACT analysis providing cost/mitigation benefit assessment of alternative control technologies, including mitigation of SOx and NOx.

Guidelines (Standards) from the B.C. Ministry of the Environment

The Panel's caution in accepting the proposed NOx, SOx and particulate emission values stems from uncertainty about the appropriate process for setting permit conditions. The Panel's Terms of Reference in this regard are novel. The tradition of the Ministry of Environment seems to have been to set the permit conditions after approval, and in direct negotiation with the industry in question.

We note the following in the Ministry's technical submission to the Panel (Sept. 20, 1990, file 359-Govt.37, p.11):

> "The dispersion modelling done by the proponent and the need for any additional work will be reviewed by Waste Management prior to any permit issuance. The Ministry of Environment will consider the sensitivity of the local terrestrial and aquatic systems to acidic deposition and consider the findings of the panel on the toxicity of chromium in the environment in determining acceptable levels."

To the Panel's concern, the Ministry of Environment did not offer their consideration of the terrestrial and aquatic systems nor their estimation of the modelling (or need for extra work) for the guidance of the Panel, nor was that advice forthcoming in the public testimony of ministry officials.

Furthermore, while the Ministry of Environment makes the comment:

> "... the SO_2 and NO_2 values are well within the objective criteria. The ministry is currently developing new Objectives for SO_2 and NO_2 which will apply province wide." (file 359, p.10).

The Panel can only surmise whether the proponent's suggested values (i.e. 177 mg Nm^{-3} NOx and SOx) will meet the new objectives for emissions, and indeed whether they will meet or exceed requirements for "the sensitivity of local ... systems" (Ibid, p.11).

Until modelling is completed, this concern cannot be addressed. The Panel notes the observation by the Ministry of Environment that:

> "... the levels proposed for the discharge of particulates (an average of 150 mg m^{-3} and a maximum of 200 mg m^{-3}) fall within the range specified in the interim objectives." (Ibid., p.10) (emphasis added).

The objectives referred to are the B.C. Ministry of Environment 1979 Objectives (file 405-govt.41), addressed throughout the hearings. If they are indeed "interim", the Panel's use for them is diminished, and the basis for judging the proponent's proposal correspondingly reduced. It should be noted that the current range of suggested particulate (18-20 mg Nm^{-3}) is an order of magnitude less than a value that the Ministry of Environment found to "fall within the range". The Panel's understanding is that such Objectives are starting points for more rigorous requirements that will of necessity arise from BACT analysis.

As identified by the Panel's consultant, Mr. Sagert (Oct.12/90: file 461-Panel.50, Attachment), the United States EPA practice is to set New Source Pollution Standards (NSPS) that apply to new facilities. These represent the most lenient standards and provide a basis for proceeding on a BACT analysis. Mr. Sagert also points out (file 461) that the U.S. EPA provides an "on line" summary of BACT analysis decisions, which can be used in *evaluating* proposals.

In British Columbia, many plants have been commissioned since 1979, and in this period NOx reduction has become common practice. For example, this is the case with power generation facilities. The proponent, the Panel and the public record would have benefitted from information regarding permit values for these new sources, if only for NOx, SOx and particulate. For example, the observation that "NOx is not specified" in reference to pulp mill permits (Transcript, p.1506) indicates a possible precedent for the current deliberations. In summary, regulatory information available in British Columbia has not been complete and this has hindered this review. Information from other agencies and jurisdictions has been utilized by the Panel and is referred to in Appendix H.

Based on its experience in this review, the Panel recommends that future Environmental Review Panels and other major project review processes have available the emission values (mass concentration and mass rate) that have been set in waste management permits over the five-year period prior to the particular assessment.

Furthermore, the Panel recommends that standard conditions (percentage O_2, CO_2 in the gas stream, temperature, pressure) be clearly stated for all emission sources, including power boilers and combined process-power-fugitive emission stacks.

The Panel recommends that the permit values in Table 3-A2 for SO_2, nitrous oxides (as NO_2) and particulate be adopted.

The Panel recommends that, for permitting purposes, the proponent should provide estimates in kg/hr. of fugitive particulate emissions from all sources.

TABLE 3-A2

PROPOSED AIR EMISSION PERMIT LEVELS

	Mass rate (g/hr)	Concentration (mg Nm^3)[1]
SO_2	4000	177
nitrous oxides as NO_2	4000	177
Particulate	400	18
Carbon Monoxide	1500	65
Chromium (total)[2]	41.7	2.0

NOTES:

1: Values are expressed in mg per cubic meter measured at 20°C and 1 atmosphere, taken as NTP, Normal Temperature and Pressure, in British Columbia.

2: The chromium content is contained in the particulate, which can therefore not exceed 10.4% Cr.

3: Opacity is not to exceed 5 percent over a six minute period; applies to stack and building.

Ambient Air Objectives -- Status of Modelling

The proponent initially applied air quality modelling techniques that were not optimum for the proposed site. This has caused considerable delay in the review process. The Panel's consultant, Mr. Sagert, based on his professional experience with the permitting process both in the United States and Canada, worked closely with the proponent's consultants to resolve this matter. He recommended changes to the proponent's modelling, such as use of the "Short Term Complex Industrial Source Model" and the "Rough Terrain Diffusion Model".

These latter two dispersion modelling programs were used in producing additional data, presented in the EIS Addendum. However, the number of receptor sites was increased from 180 to only 252, rather than the recommendation of more than 1000, and the stack parameters (especially at the 60 meter height) did not address the matter of "Good Engineering Practice" in the selection of stack height. Indeed, it is important to note that Mr. Sagert, during the hearings, presented evidence of the detailed approach undertaken in the State of Washington (pursuant to EPA guidelines) in coping with the obvious logical contradiction of raising stack height, without reasonable limitation, until ambient air objectives are reached *by dispersion* (Transcript, p.1137). Subsequently, as later presented at the hearings, calculations were provided for a 34 meter stack under various conditions (dilution air).

Complete stack parameters (diameter, height, gas exit velocity, and gas exit temperature) are not consolidated for the public record in either the EIS Addendum or the Seventh Supplemental Submission (file 544: Table 5.2.B). For example, stack diameter is 0.79 meters in the EIS Addendum, yet 1.6 meters in the presentation notes of one of the proponent's experts (Kessler: file 402-Pro.61).

It is noted that Environment Canada, in their assessment of the EIS Addendum, makes the following statement:

> "The second set of models applied by RESCAN Environmental Services Ltd., the U.S. EPA Short Term Complex Industrial Source model and the Rough Terrain Diffusion Model, are recognized to be state-of-the-art for this type of application. However, the air concentrations and depositions of the identified smelter emissions, estimated by these models, have not been adequately documented and presented for review at this time.
>
> Through verbal communication with the consultant, RESCAN ..., Atmospheric Environment Service (of Environment Canada) has determined that appropriate application has been made of the available meteorological data for the Port Hardy study area. However, the

> datasets used as input to the air quality models have not been completely documented and presented for review.
>
> Based on the above circumstance, Atmospheric Environment Service believes that RESCAN ... have undertaken to apply appropriate assessment models to the Sherwood Ferrochromium Project. However, an assessment of impacts on ambient air quality and deposition resulting from the smelter emissions must be withheld until Atmospheric Environment Service has had an opportunity to review the air quality model results and the associated meteorological input data." (File 357-Govt.35. p-9-10).

Sherwood's lack of suitable presentation information on the air modelling in the public record makes proper public deliberation of the environmental impact difficult. The concentration of total chromium, or Chromium VI, experienced in ambient air outside the plant and in inhabited areas nearby is critical. In turn, these values depend on the parameters (concentration in ug m^{-3}) determined by dispersion modelling at an emission rate of 1 gram per second, as produced by the computer projections.

Specifically, the Panel has had difficulty translating the total gas stream data of Table 4-10 B (file 544-Pro.91) into exit parameters from the stack, in order to fully interpret the ambient air concentrations and comparisons given in Table 5.2 C (file 544). The Panel disagrees with the proponent's suggestion that if a 60 meter stack largely satisfies the Ambient Air Quality Objectives of both British Columbia and Canada, then the decision can be made without further modelling and analysis, based on "Good Engineering Practice".

For example, Environment Ontario's discussion paper "Stopping Air Pollution at its Source" (Clean Air Program) is instructive (file 426-BI.39). Significantly, it designates SOx and NOx as BACT pollutants, and also specifies "the best control technology available (or its equivalent) anywhere in the world for the most hazardous pollutants". Chromium VI falls into the latter class, and is controlled through application of the latter definition, which is a Lowest Achievable Emission Rate (LAER).

For our present discussion, the comments on stack height are important:

> "As a reinforcing measure for the concept of using modelling as a "second line of defence" for the environment [i.e. in addition to emission rate control], it is also possible to place a limitation on the maximum stack height which can be used for modelling. Using such a system, a proponent would be allowed to build any height of stack but would not be allowed to use a height greater than such a limit in performing modelling.
>
> "Using smaller stack heights in the models, greater concentrations are predicted. Thus, if air quality is a concern due to existing sources in a region, such a rule places greater

emphasis on the need for better control technology than that dictated by the contaminants involved, without specifically requiring it. Better technology would have to be used because it would be hard to meet the air quality standards without it.

"In the United States, a code known as the Good Engineering Practice (GEP) rules is used in such a fashion; these rules limit the stack height which can be used for modelling to 2.5 times the height of the associated building or structure. The problem with this approach is that exceptionally tall structures may permit the use of stack heights greater than might be desired. Other options for such a limit include a fixed height above the top of the building/structure, or simply an absolute limit on the height which can be used in the models.

"Generally, limiting the allowance for stack heights in dispersion calculations would have the effect of limiting actual stack heights as well as encouraging improved technology. Short stacks are, for the most part, preferable to tall stacks on aesthetic grounds and because they restrict the radius of influence of emissions from plants." (file 426-BI.39, p.19)

The 60 meter stack height would be in excess of the 2.5 ratio of the EPA, and it is noted that this design would be rejected in concept by the Ontario Ministry of Environment. It may not represent a suitable basis for judging the ambient air levels that may be expected to be created by a plant. The Panel notes that at a ratio of 2.5 (stack height to building height), a 34 meter stack corresponds to a building height of 45 feet, approximately that of the current facility.

Therefore, while re-iterating the absolute condition of requiring further air modelling analysis, the 34 meter stack, and the maximum values for SOx, NOx and particulate are compared.

For sulphur dioxide, the maximum value of 197 ug m^{-3} (1 hour) compares favourably with the 450-900 (B.C. Ministry of Environment, 1979) and the 0-450 ug m^{-3} Canadian Clean Air Act value. (Interestingly, the proposed Ontario one hour maximum is much higher, namely 690 ug m^{-3}).

For nitrogen dioxide, the maximum value of 197 ug m^{-3} also compares with the Canadian Clean Air Act value of 0-400 ug m^{-3} (considered acceptable), and the 24-hour value of about 35 ug m^{-3} compares favourably with the nitrogen oxides value from Ontario of 200 ug m^{-3}.

For particulate, the proposed Sherwood emission standard must be recognized as linked to the total chromium standard. Accordingly, if the particulate is 10% by weight chromium, it is that the proposed particulate value is 20 mg Nm^{-3} (as suggested by Sherwood) if the total chromium level is set at 2.0 mg m^{-3} (see Section 3.2).

Predicted ambient values of NOx, SOx and particulate, based on the 34 metre stack (no dilution) are still well within national ambient air quality guidelines.

It is recommended that the proponent complete its air modelling on the basis of a 34 meter stack height, in accordance with the GEP guideline for maximum stack height to building height ratio of 2.5. Dilution air should not be used.

Other Airborne Contaminants

Trace elements in raw materials, principally coal and chromite ore (refer to Section 2), give rise to contamination of the gas stream by arsenic, zinc, and heavy metals such as cadmium, lead and mercury. In addition, organic materials (primarily PAH -- polynuclear aromatic hydrocarbons) have, in principle, the potential to survive through the gas system particularly during charging steps, and as a function of the volatility of the coal reductant that is used.

As a source of SO_2 variability, the proponent cites "organo sulphur volatilization", which is the escape of sulphur-containing organic compounds during the charging of the coal. By the same token, PAH's are possible.

The Panel recommends that any permit issued should specify that organic compounds (specifically PAH) should not occur at any detectable level in the stack gases.

For actual levels that could be entertained in the emissions, the values proposed by Mr. Lemmon (file 393-Pan/Ex.31, and in revised form in file 554.PS-236) appear to approach BACT for smelting and refining of metallic ores:

TABLE 3-B1

Recommended Emission Levels: Other Contaminants (after Lemmon)

Substance (in mg Nm^{-3})	Emissions Initial (file 393)	Emissions Revised (file 544)	
Chromium	1.5	2.0	
Lead	0.1	0.1	
Zinc	0.6	1.0	
Arsenic	0.01	0.03	
Mercury	0.001	0.01	
Dioxins	0.5×10^{-6}	(same)	(a significant problem if any scrap is used)

TABLE 3-B2

Comparison of Emission Rates and Ambient Levels

	Emission Rate (mg Nm^{-3})			Ambient Levels (ug m^{-3})** (34 meter stack)			
	Proponent 0°C	Proponent 20°C	B.C. Object.	Pro-ponent	B.C. Object.	Ont. Object.	U.S.Clean Air Act*
Chromium	2.4	2.2	--	0.12	0.05	1.5	2.5
Lead	0.1	0.093	7.14	0.017	1.0	5	*** not included
Zinc	3.8	3.5	7.14	0.68	1.0	100-120	*** not included
Arsenic	0.25	0.23	7.14	0.042	0.1	0.3	1.00 max.
Mercury	0.01	0.01	1.338	0.0017	0.1	2	0.25 max

(1 hour)

* Maximum at plant boundary

** 24 hour values

*** As quoted in Pitchers: file 421-Pro.67

The Panel recommends that with regard to emissions for chromium and trace elements a conservative approach should be adopted by setting the revised values given in Table 3-B1 (Section 3.3.2) as permit levels.

The need for intensive monitoring including trace analysis must be emphasized. The Panel notes that arsenic build-up in the baghouse dust rather than zinc was concluded by the proponent on theoretical grounds, following the first session of the hearings. It is apparent that Sherwood's proposed levels of air emissions for all of the trace elements are based on engineering estimates only. If the proponent agrees to a slate of BACT trace element emission levels without the benefit of pilot facilities, then the onus must be on the proponent to achieve these levels.

As any approval-in-principle of this project is contingent on the data on hand, any substantial upward revision of the proponent's emission levels, for example for hazardous trace metals, would negate the basis for that approval. It should be noted that the evidence does not disclose a particular problem with respect to trace elements. Nevertheless, this should be a risk that the proponent should be bound by in the permitting process as a clear consequence of the proposal to utilize the melter for an application (i.e. high carbon ferrochromium manufacture) for which it has not previously been tested. Table 3-B2 (following page) compares the proponent's suggested levels with various objectives.

From this comparison and the preceding information, it is clear that the proponent's and Mr. Lemmon's figures are quite comparable in terms of the lead and mercury levels, but not the arsenic and zinc levels. Significantly, it is the latter two elements where the B.C. Ambient Objectives are most closely approached.

3.3.3 Deposition From Air Emissions

Air emissions, particularly NOx, SOx and particulate (especially chromium), are potentially a critical source of impact to marine, aquatic and terrestrial ecosystems. Trace elements may also be of concern. This is due to the process of deposition of these materials from the air mass. Appendix I is a background discussion of the process and significance of deposition of these substances. Appendix J is a review of the information available to the Panel for this assessment.

The purpose of this sub-section is to provide sufficient background for the assessment of the impacts of deposition, based on available information, in Section 3.4 (Freshwater and Marine) and Section 3.5 (Terrestrial).

Particulate Deposition

Particulate deposition is important in this review because of the Chromium and trace metal content of the solids passing the baghouse. The chemical nature of this material -- whether highly insoluble chromite (or diopside) as proposed by Dr. W. Hartford (file 494-Pro.83, p.3) or more available in the environment (as expressed by Dr. Nriagu in file 504-Govt.51) -- must remain a matter of speculation for the Panel. It is a theoretical debate until the bioavailability (acid solubilization) of the stack emissions can be tested.

The Panel cannot be certain of the exact ratio of CrVI:CrIII in the material. In the Seventh Supplemental Submission (file 544-Pro.91), the ratio of 1:5000 is given; lower values are cited in the EIS Addendum (file 335-Pro.33, Table 4.8), namely about 0.2% for Lehigh Stainless Steel or 1:500. Whether Chromium III will be converted to Chromium VI by oxidation in aerosols or surface water by hydrogen peroxide, as suggested by Dr. Nriagu, must be resolved by further science. The Panel does note that aerosols also contain such reducing agents as bisulphite (HSO_3.), which is formed directly by the reaction of SO_2 with water. Drinking water purification by chlorine and sewage effluent treatment by chlorine introduce oxidizing agents capable of converting Chromium III to Chromium VI. However, the persistence of residual chlorine is so low in the sewage at the point of outfall that the potential for oxidizing chromium in Hardy Bay will be extremely low.

Faced with these uncertainties, the Panel first looked for methodology and data related to bioavailability of chromium in particle emissions (from high temperature processes). Data is sparse.

Two systematic studies are available, by Cox et al. (1985) and Butler et al. (1986), as quoted in file 425-BI.38, 4.3). Notably, it is observed that:

> "...acid-base leaching extracted approximately half of the total chromium of which about 40 percent was CrVI (*i.e. and the remainder CrIII*)".*

In summary, one experimental study of the particulate from the smelter will indeed be worth a thousand words. The prudent assumption is to maintain total chromium emission as the standard, with a conservative estimate of CrVI, and to consider possible impacts on the marine and freshwater environments from the perspective of a worst case scenario. This means that it should be assumed that all chromium is bioavailable and may have the potential toxicity of CrVI to biota in the receiving environment.

Assessing Deposition Impacts: Background

The available data and information regarding deposition resulting from the Sherwood plant is not straightforward. The data presented in the EIS and the EIS Addendum were subjected to close scrutiny at the hearings. Inadequacies resulted in the Panel requesting further clarification from the proponent with regard to wet and dry deposition of chromium, SOx and NOx (file 440-Panel.49, p.2).

As the proponent did not provide sufficient response, the Panel finds it difficult to provide definitive comment on the environmental impact from total deposition on water and soil.

.....

*

Cox, X.B., III; Linton, R.W.; Butler, F.E. (1985). "Determination of Chromium Speciation in Environmental Particles: Multitechnique Study of Ferrochrome Smelter Dust". Environmental Science Technol. 19: 345-352.

Butler, F.E.; Knoll, J.E.; Midgett, M.R. (1986). "Chromium Analysis at a Ferrochrome Smelter, a Chemical Plant and a Refractory Brick Plant". Journal of Air Pollution Control Assoc. 36: 581-584.

From the proponent's existing data, it could be observed that:

(1) Incremental values for soil concentration of chromium are given as 2 mg in 25 years for soils with an average current level of 60 mg kg^{-1}. If true, these would be minor impacts. However the Panel notes that the New Jersey Department of Ecology has recommended a clean-up level of only 75 mg kg^{-1}.

(2) For sediment, assuming all particulate reaches the surficial layer and that the density is approximately analogous to soil, material would contain per the proponent's calculation 2 mg of incremental chromium over current levels of 20-40 mg. If the data can be relied upon, this is a manageable impact.

The depth of surface layer of either sediment or soil is unspecified in the EIS Addendum, page 5.23. The consultant to the intervenors, Dr. Caton, has conducted calculations based on 2×10^5 kg/ha. corresponding to a one centimeter depth (file 268-Pan/Ex.11). He estimates an increase of 90 or more milligrams per kilogram of chromium over a 20 year period. The proponent appears to select a weight of soil of 2×10^6 kg. per hectare, an apparent depth of 10 centimeters (EIS Addendum, p.5.23). This has the effect of reducing the proponent's estimation of impact. Were the loading in the sediment surface layer to reflect Caton's calculations at the 19 mg m^{-2} y^{-1} deposition rate, a significant alteration of estimated quality could result.

Notably Table 5-27 (EIS Addendum), giving values for trace metals such as arsenic and zinc, is in error due to drastic revision of the outputs, as presented in the Seventh Supplemental Submission. **The Panel recommends that the proponent undertake a complete revision and summary of the deposition data.**

Despite the present state of the data, it is possible to draw some general conclusions regarding depositional impacts. These are offered in appropriate subsections of Section 3.4 (Freshwater and Marine) and Section 3.5 (Terrestrial).

3.4 FRESHWATER AND MARINE IMPACTS ASSESSMENT

3.4.1 Overview

This section of this report deals the range of possible impacts of the Sherwood facility on freshwater and marine environments, including the resident organisms. The major areas of interest are physical effects, effluents, and deposition from air.

The B.C. Ministry of Environment, Environment Canada, and the Department of Fisheries and Oceans all stressed the major importance of Hardy Bay as a "rich and productive marine and intertidal environment". Specifically, the intertidal and subtidal zones provide habitat for a considerable range and abundance of marine life, such as marine and salmonid fish species, invertebrate species, shellfish (including abalone, clams and geoduck), crab and octopus. The Quatse River is a salmon spawning stream of major local importance; a hatchery is located on this stream. Numerous vegetative species typical of the coastline flourish in the Hardy Bay area, and specifically at the Bear Cove site and the islet to be used for the docking facility.

In addition, the B.C. Ministry of Environment and Environment Canada cite the use of Hardy Bay, including the foreshore areas, by migratory birds, particularly in winter. Also, the B.C. Ministry of Environment (Morrison: file 528-Govt.57) advises that the Quatse River Estuary has been "reserved" for protection of fish and wildfowl habitat. Further information (file 528) indicates that (1) out of 27,000 kilometres of coastline in British Columbia, only 2.7% is estuarine habitat, (2) there are only six estuaries on the east coast and one on the west coast of Vancouver Island and (3) the Quatse River estuary (at Hardy Bay) represents approximately 10% (about 200 hectares) of the estuarine habitat on Vancouver Island.

Physical effects on water bodies are limited to the disturbance of shoreline through construction of wharf and bridge structures at Bear Cove and the nearby island, potential blanketing or smothering of benthic organisms and habitat by spillage of chromite ore and other raw materials during unloading, and a minimal disruption of the small streams on site. On a temporary basis, silting from soil erosion during the actual construction of the buildings on the site could have a habitat-destroying effect. Long term silting from uncontrolled storm runoff through overloading of the holding ponds would have the same physically damaging effect. In addition to the physical

impact of siltation, spillage of chromite ore and other raw materials also involves the potential for chemical contamination.

Effluent discharges are of particular interest. Of these, the most obvious are from the thermal effects of the discharge from the seawater heat exchanger. There is also sanitary sewage disposal in the same pipe. Intermittent direct impacts, still largely indeterminate, arise from (a) storm water disposal after treatment and analysis, (b) excess "blowdown" water from the process loops that may require purging after treatment. The final water circuit diagram (Drawing D3586, file 386-Pro.51), presented by Rescan Environmental Services Ltd., makes provision for the bleeding of treated process water. In addition, net water consumption by the fiberization process has been eliminated. Water balance, particularly as it affects demands on the local water supply, is in itself an environmental concern.

Deposition of emissions, as noted in the Overview, probably constitutes the major potential for impact. In particular, it is important to focus upon the fallout of acidic material (sulphate, etc.) and particulate matter, especially chromium. Such impacts, determined by air dispersion, can extend well beyond the localized source. Therefore, such deposition has the potential of affecting juvenile salmon habitat (Quatse River), the water supplies of nearby communities, and the ecosystems of Hardy Bay and possibly the adjacent coastal waters. Effluent and runoff are dependant on currents and other water circulation processes for distribution of impacts, so that detailed hydrographic data become as critical for assessing impact as is the computer modelling for air dispersion. Since the timespan for the particles to be suspended in water columns will be comparatively short (perhaps a few weeks), it is the sediment of streams and of the marine ecosystem which will be the final repository of particulate materials.

The proponent, in preparing the EIS, conducted limited baseline studies of the intertidal and subtidal zones, relying largely on generalized government information sources (file 444-Pro.75). As a result, the material presented is insufficient to constitute an adequate baseline profile that describes the ecology of the area. Few species are identified, assessments of population sizes are absent, and there appears to be insufficient information on which to base accepted biodiversity indices. Based upon available data, the assessment of the aquatic effects of the project must be generalized. In part, the Panel must also estimate ecosystem values from assessments by responsible government agencies.

3.4.2 Heat Exchange System

The seawater heat exchanger raises two environmental issues that warrant consideration: (1) direct effects to small marine life entrained in the intake water; and (2) the thermal effects of the heated discharge.

Direct Effects on Marine Life

The design of the intake facility is presented as meeting the "Preliminary Draft Marine Intake Fish Screening Directive" of May 1990 (file 445-Pro.76), though no details of the intake being "more than 2 kilometres from herring spawning areas" were given. More concern involved loss of organisms farther down in the food chain, specifically zooplankton and copepods.

This concern was dealt with in testimony by Dr.A.G. Lewis, who estimated that a small fraction of the total plankton population of Hardy Bay would be physically destroyed. Concentrations of zooplankton at the 50 metre depth, and the exact velocities of water along the intake pipe were concerns of representatives of the United Fishermen and Allied Workers' Union. At the volumes of water involved, 25 m^3 per minute, as compared to a large power plant using 3200 m^3 per minute, Dr. Lewis forecast that there would not be a significant depletion of the zooplankton populations in Hardy Bay.

Other effects on marine life could arise from the use of biocides ,such as algicides, to prevent fouling of the intake pipe. The proponent does propose using these agents, most likely copper oxide, "on the inlet and possibly the outlet structures" (Lewis: file 284-Pan/Ex.13, p.3). Lewis further notes that "the amount of copper antifoulant and the dilution capability of the effluent as well as the surrounding water is adequate to minimize damage to organisms that are not directly on the inlet and outlet structures". In addition, the potential for other "opportunistic" organisms that are more invasive was raised at the hearings.

It is recommended that the monitoring program should include observation of the effects that biocide treatments have on marine life.

The Panel observes that (1) introduction of additional biocides and (2) alternative contingency cooling (and sewage disposal) may be issues faced by the proponent if an unforeseen accumulation of marine life occurs.

It is recommended that the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment should require the proponent to obtain approval in advance of any alterations to the operation and cleaning of the seawater discharge pipe.

Based on its analysis of the evidence, the Panel concludes that it appears that the heat exchange system would not have a significant physical effect on marine life.

Thermal Effects

Design of the diffuser outlet system (25 m^3 per minute), located at a depth of 50 metres and apparently 500 metres from shore, was presented as providing a significant dispersion of the thermal plume exiting at 5°C greater temperature. The width of the zone at the "trapping depth", where the plume would be concentrated, was projected to be 15 metres, with a temperature variation of less than 0.1°C being achieved within 20-50 metres of the diffuser outlet. Much lower values of temperature rise were projected along the "lateral entrainment" zone. (file 445-Pro.76)

It is noted that this is a lower projection for temperature rise than considered by Dr. Lewis in estimating impact (see below). Also, the B.C. Pollution Control Ambient Objectives specify 1°C at 100 meters.

In spite of these design projections, the Panel is mindful of the following discrepancies:

(1) The original waste permit application suggested a temperature rise of 6°C at the outlet.

(2) The EIS suggested a temperature rise of 10°C at the outlet, then this was revised to 5°C in the EIS Addendum.

As well, the Panel remains aware of the initial concerns of its oceanographic consultant, Dr. Lewis, that a thermal bloom of plankton species harmful to fish, such as "heterosigma or one of the

Bodecaceria species" (Transcript, p. 2123), could occur if the average Hardy Bay temperature were to rise.

The Panel is persuaded by evidence examined at the hearings that the temperature rise between the intake and outlet pipes would not exceed 5°C. This would result in a maximum 1°C rise at a 100 meter radius from the outlet. Dr. Lewis concluded that this would not be sufficient to induce any significant thermal effect on Hardy Bay or the local area, and there would not be a cumulative thermal effect.

The Panel notes Dr. Lewis' comment regarding the proponent's commitment (EIS Addendum: file 335-Pro.33, p.7-5) to monitor seawater inlet and discharge temperatures:

> "No details are given, of how this is to be done or what will be done with the information or what the critical levels are." (file 361-Pan/Ex.26, p.5).

It is emphasized that the information transfer to external agencies and the values where action must be taken must be integral aspects of a successful, meaningful monitoring program. The lack of detail presently available makes monitoring provisions all the more imperative for this project.

For example, as the B.C. Ministry of Agriculture and Fisheries has stated:

> "The impacts of industrial thermal plumes have been well documented by a number of agencies which has resulted in permitting refinements for such discharges. No reference to thermal discharge standards is made in the EIS, nor is there a statement that the discharge is expected to comply with regulatory requirements." (file 309-Govt.28).

The British Columbia standard, as contained in the ambient (receiving waters) control objectives is "to be within 1°C of the natural level" but applicable outside the initial dilution zone (file 405-Govt.41, p.13). That zone is defined as "extending up to 100 metres horizontally in all directions but shall not exceed 50% of the width of the water body". However, it is not allowed to "intrude on shell fish beds, restricted routes known to be followed by migrating salmon and trout and other significant biological resources". (Ibid.)

It is concluded that, on the basis of the proponent's information and Dr. Lewis' assessment, the thermal effect of the seawater discharge should prove to be a manageable impact, provided this effect is encompassed within a monitoring program.

The Panel recommends that the intent of the British Columbia regulations, with respect to thermal effects, should be followed in regard to any permits issued for the Sherwood plant.

The Panel recommends the development and publication of guidelines for thermal discharges to marine and freshwater bodies in British Columbia.

It is further recommended that the temperature at the outlet and the temperatures at successive radii (20, 50, 100 meters) be measured during the start-up period under a variety of current conditions to verify the engineering estimates.

Monitoring Considerations for Seawater Coolant Discharge

The uncertainties cited by the Panel in this section tend to reinforce the strong conviction of the Panel's consultant, Dr. Lewis, regarding the need for baseline data. Background hydrographic information, on a one year study basis, is still necessary in order to provide a data base suitable for monitoring the effects of the outfall.

In particular, Dr. Lewis states and the Panel concurs that:

> "Recalculation of the temperature increase of the cooling saltwater provides an estimated increase of approximately 5° rather than 10°. This noticeably reduces my concern about the potential impact of the heated effluent. I still believe that background hydrographic information is essential to an understanding of the distribution of effluents and materials accidentally introduced into the marine environment from the plant and loading dock. The collection of these data could, however, be done during construction of the plant." (file 361-Pan/Ex.26, p.3-4).

Furthermore, the hydrographic program is described as:

> "Temperature, salinity and oxygen data should be collected quarterly, for one year. Station selection should consider the site location and the direction of transport of any effluent. (See 11 m. current data for April, 1990.) Note that oxygen measurements were not taken during the April data collection. Oxygen levels are extremely useful in determining water exchange as well as a number of other factors.
>
> "Note that the sampling program and the station sites are not provided in the Addendum. This must be done. The lack of information in Section 6.2.4 (page 6-8) gives the company the right to sample whatever and wherever they wish. They must provide a suitable schedule of events, places, depths and times. They must measure dissolved oxygen levels at appropriate levels in the water column." (Lewis: file 361-Pan/Ex.26, p.4).

Finally, Dr. Lewis observes that:

> "Routine testing for sewage coliforms from the plant should be continued monthly until the plant has been operating at full capacity for 6 months. Testing should be from the saltwater cooling effluent pipe after introduction of the sewage." (file 361, p.5).

The Panel supports Dr. Lewis' emphasis on the importance of detailed definition of the baseline studies program.

It is recommended that the full and satisfactory description of the marine baseline research program must be a condition for this project to proceed.

It is further recommended that the baseline research requirements be specified by the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment.

3.4.3 Storm Water and Other Effluent Discharges

Section 2.6.5 outlined the process technology involved in handling storm water and process water. In this section, this information is analysed in regard to environmental impact.

Discussion

The proponent has proposed that there would be zero discharge of effluent, other than the heated seawater and some treated sewage. The practices that will actually be used to achieve zero effluent discharge, as committed to by the proponent, are not established in any of the proponent's submissions in sufficient detail for BACT evaluation. Even with the water balance figures submitted (file 544-Pro.91), the following are unclear:

(1) The volume of purge or blowdown water that will be released from process water storage due to build-up in the recycling loops.

(2) The sequence of short term storm water storage and real time compliance testing to permit immediate overflow discharge.

(3) The use of direct overflow into streams or onto the foreshore rather than use of an outflow pipe for (1) and (2).

(4) The capacity of the proposed activated carbon treatment system to accommodate non-compliance storm water in volume (Fig. 2.9, EIS Addendum, and Transcript pp.131-132.)

Most modern blowdown or central water treatment facilities that qualify as BACT, treat water that is supplied to the individual process units. These facilities feature suitable lagoons or storage facilities for both storm water and excess process water; these are of such capacity to allow for ballast capacity in case of failure of the treatment plants, to allow for back flushing or to allow replacement operations on filtration units, etc. Many involve active filtration beds for storm water rather than sedimentation alone. Many such BACT facilities judge final water quality at the lagoon exit point rather than at the blowdown treatment plant.

The fact that Sherwood does not adequately address such considerations in its plant design indicates that the Sherwood facility may not be zero discharge by design, and has had no BACT analysis applied to it.

TABLE 3 - C

COMPARISON OF POSSIBLE STANDARDS FOR EFFLUENT AND STORM WATER DISCHARGE
(Units are mg per litre^{-1})

	B.C. MoE (1979)	Panel's Proposed Standards (from Lemmon, file 393: Process & Contaminated Storm Water*).
TSS	25 - 75	10.0
Oil & grease	10 - 15	1.5
Ammonia-N	1.0 - 10	1.0
Cyanides	0.1 - 0.5	0.08
Phenols	Not Specified	0.005
Chromium total	0.05 - 0.3	0.05
Lead (total)	0.05 - 0.2	0.15
Zinc (total)	0.2 - 1.0	0.18
Aluminum	0.5 - 1.0	0.1
Antimony	0.25 - 1.0	0.05
Arsenic (total)	0.1 - 1.0	0.04
Beryllium	Not Specified	0.02
Cadmium	0.01 - 0.1	0.001
Copper	0.05 - 0.3	0.1
Mercury	Nil - 0.005	0.001
Selenium	0.05 - 0.5	0.01
Dioxins	Not Specified	0.000015
pH units:	6.0 - 8.5	

* Contaminated Storm Water is defined as any water coming in contact with raw materials, intermediate or final products and process areas. (Note that this definition has implications for slag leaching).

It is recommended that any approval of the environmental acceptability of the Sherwood's water treatment proposal must be made on the basis of clarification of:

(1) Storage capacity for unusual events rapid, heavy rainfall at night or during plant shutdown conditions. The proposal to sample and then discharge storm water is not considered to afford adequate environmental protection.

(2) Discharge method and location.

Sherwood has proposed that any water that must be purged, or released in the event of storm overflow, would meet the 1979 B.C. Ministry of Environment Objectives for effluent discharges to freshwater and marine environments. Somewhat surprisingly, the technical assessment of the project by the Ministry of Environment made the following comment regarding contact or process water:

> "The effluent quality will be required to meet the limits specified in the "Pollution Control Objectives for Mining, Smelting and Related Industries of British Columbia". (file 359-Govt.37, p.8).

The Panel takes the view that this was an observation on the minimum standard, and that BACT requirements, possibly in excess of these standards, were intended to be recommended by the Panel for these effluents, just as in the case of air emissions.

Therefore, in Table 3-C (previous page), the 1979 Objectives are compared with those suggested by Mr. W. Lemmon, based on his knowledge of BACT requirements in related integrated iron and steel facilities.

The Panel recommends that the most appropriate criteria for pollutant discharge for application to the Sherwood plant are those given in Table 3-C, as supplied by Lemmon.

Furthermore, the Panel recommends that:

(1) These criteria should not be subject to variance during periods of excess runoff as proposed in the 1979 Objectives.

(2) Bioassay must meet 96-h LC (lethal concentration) at 100 percent survival for 100 percent strength waste water, both on a static and flow-through basis using salmonids.

(3) Daphnia Magna acute lethality toxicity testing must be applied.

(4) The total suspended solids (TSS) must be subject to meeting the total chromium requirements (i.e. at 10 mg L^{-1}, the percentage of chromium in the TSS should be such that the total chromium value of 0.05 mg L^{-1} is achieved).

(5) Compliance must be achieved by process (blowdown) and storm water separately. Dilution of one by the other is not to be permitted.

While the Panel recognizes that these are stringent criteria, it is asserted that such measures are necessary in order to avoid impact to the marine ecosystem from such discharges.

3.4.4 Direct Impacts on the Foreshore and Marine Habitat

Physical Site Disturbance

In reports following the EIS Addendum, Environment Canada (file 479-Govt.46) and the Department of Fisheries and Oceans (file 377-Govt.39, p.3) both opposed the creation of a raw materials storage facility on the foreshore zone, as had been proposed. For example, Environment Canada observes that:

> "... placement of fill as proposed (for the pad) on a valuable intertidal area (is an) environmental concern. The loss of migratory bird habitat for the purpose of obtaining some flat land for material storage is unacceptable".

In response, the proponent withdrew this design proposal (on October 18, 1990), and proposed to store the raw material on an upland site.

The second major foreshore concern was the construction of a causeway (earthfilled road) to the islet, connecting it to the adjacent upland site. Concerns were expressed that such a causeway would destroy intertidal habitat and alter inshore currents. Subsequently, this proposal was replaced by a bridge. Still, the Department of Fisheries and Oceans remains concerned:

> "The concept of using a bridge to the island versus a causeway assures us of a smaller loss of fish habitat. The use of a floating dock will also reduce the potential loss of habitat as compared to a filled structure. However, the statement (Addendum 5-44) that a bridged access and loading dock will benefit fish habitat by providing shading and overhead

> protection from avian predators is incorrect. The shading will reduce productivity of the kelp beds which they (the bridge) will cover and, if anything, the presence of additional perch surfaces along the access and dock will provide avian predators with more access to marine organisms." (file 377-Govt.39, p.5)

Furthermore, the loss of an important kelp bed is identified:

> "The dock will eliminate most of the Macrocystis bed it shades as well as the understorey algaes. We will assess the suitability of situating an artificial reef constructed of blasted rock on the adjacent foreshore. New reef creation must not impact habitat which is already functioning." (file 377, p.5).

The physical effects of the bridge and dock structures are expected by government experts to adversely affect habitat even in the absence of spillage.

The responsible government agencies clearly wish to ensure that the marine and estuarine ecology of the area, including migratory bird habitat, is impacted as little as possible. For example, early in the process Environment Canada requested that "protection for this (very productive marine and intertidal) environment by means such as a shoreline leavestrip of natural vegetation is also to be provided". (file 130-govt.12).

The Panel recommends that, as a condition of constructing the plant at this site, a shoreline buffer zone sufficient to protect the current abundance of foreshore habitats and species, should be part of the prescribed development plan.

Even with such a buffer zone in place, certain activities of the plant will involve the immediate marine environment. It appears that it is likely that the establishment of the facility at this location would have some physical impact on the foreshore and near-shore ecosystems in the vicinity of the development. However, it is unlikely that these direct site-specific physical impacts would have any significance for the general marine and aquatic productivity of the Hardy Bay and Quatse areas.

Spillage and Silting

There are two distinct phases of the project where physical covering or blanketing the intertidal and near-shore subtidal zones may occur.

The first is during construction. The Panel is mindful of the advice of its consultant, Dr. Lewis, with regard to the biological impact of the construction activities, particularly in connection with the pier and intake and effluent lines:

> "Siltation is likely to occur. This will affect intertidal and subtidal benthic fauna and flora. With precautions (monitoring included), this should be minimized as long as the described methods of construction are followed. I strongly suggest a preconstruction and post-construction monitoring program to determine impact." (file 361-Pan/Ex.26, p.2).

It is observed that if this project were to proceed on this site, caution must be exercised in order that the intertidal and subtidal ecosystems of this previously undisturbed area remain substantially undisturbed.

The Panel recommends that the construction and development plan for the site should be guided by the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment, with attention to minimizing impacts to either of the two unnamed streams which cross the site and drain onto the foreshore, and to avoiding soil-laden runoff and slippage directly onto the foreshore.

In this regard, it is important that "good construction practice" include adequate consideration for heavy rainfall events typical of the region.

The second physical impact issue is perhaps the more significant. This is the impact of the covering of foreshore and subtidal ecosystems by (1) spillage over time of ore and other raw materials during offloading of ships or barges and (2) uncontrolled washdown by heavy rains of raw materials on the site. This concern is quite independent of the possible chemical effects of the material, which is treated in Section 3.4.4 (Sediment Contamination).

This impact is cumulative and, by virtue of the particle size of the coal and chromite ore, can affect a relatively broad area. The proponent estimates that approximately 0.1% of the raw materials may be spilled, and while some of this may be spilled on land and some may be recovered, it is alarming

that this percentage could represent as much as 140 tonnes of material annually, as introduced in Section 2.1 of this report.

The schematic nature of the proposal provided at the final hearing, and in information to Mr. R. Snow from Mr. R. Pitchers (file 576-Pro.99) leaves uncertainty as to the direct spillage problem. In particular, the steel fabricated apron with flexible skirts is insufficiently defined in terms of (1) usage at other locations/installations, (2) efficiency, and (3) its relationship to a summary of BACT Technology for offloading.

The following comments of Environment Canada, in reference to the design available for scrutiny at the hearings, is noted:

> "From our previous experience the proposed handling of bulk metal concentrates will result in the release of unacceptable amounts of chromite ore into the marine environment." (file 479-Govt.46, p.2)

The Department of Fisheries and Oceans states that:

> "Recent work done in Vancouver Harbour (Goyette and Boyd, 1989) clearly demonstrates that there is a significant contaminant loading associated with bulk handling facilities in the harbour. It would seem that despite the best attempts to eliminate deposition of materials, that it is almost impossible to do so." (file 377-Govt.39, p.3).

The Department of Fisheries and Oceans also observes the proponent's estimation of 0.1% spillage (in operations on site) (file 335-Pro.33, p.2-24), and concludes that:

> "If this is a valid approximation of the potential spillage at the docksite, there is a significant concern for sediment contamination and smothering of benthic epifaunal and infaunal species at least in the immediate area." (file 377-Govt.39, p.3)

It is recognized that the proponent believes (Snow: file 559-Pro.95, p.23) that the new conveyor system, with hooded transfer points, and the new unloading system represent a sufficient response to the problem. Still, the final comment is:

> "Sherwood acknowledges that there will continue to be some spillage during the unloading of chromite ore. However measures are proposed to control this." (Snow, Ibid.) (Panel's emphasis).

From this statement, it appears that the amount of spillage and the control measures are as yet undetermined. It is clear that there is a need for further design work and these new designs must

be carefully assessed in terms of the prevention and retention of spills in all types of off-loading conditions.

The proponent contends that the chromite ore will only physically affect the bottom sediments and the marine life at that location; specifically a "loss of marine plants". (Habitat for all the intertidal and subtidal flora and fauna will be destroyed where the deposition occurs). The Panel's expert, Dr. Lewis, agrees, although including other shipboard debris in his concerns (file 361-Pan/Ex.26, p.1). Dr. Lewis contends and the Panel concurs that both of these factors will likely cause the reduction or elimination of the kelp bed in the vicinity of the docksite.

Unless a far more contained unloading system can be devised, such that this spillage is significantly reduced, it is the Panel's view that this impact would likely overwhelm any other efforts to conserve the local intertidal and subtidal ecosystems. Refer to recommendations of Section 2.1.

3.4.5 Sediment and Water Contamination

The potential for the chemical contamination of the sediments of freshwater and saltwater bodies is an important issue. The primary sources of contaminants would be the spillage of chromite ore near the dockside, the discharge of contaminated water from the site, and deposition of chromium, NOx, SOx and trace elements from the air.

Appendix I presents a background discussion of the issue of sediment loading and of the reference data and standards that are available for consideration, including the basis for the standards set in this report. Appendix J presents a summary of information about deposition from the Sherwood plant. Appendix K discusses the toxicity of chromium to marine and aquatic organisms. Appendix M provides background information regarding water quality objectives.

Solubility of Chromite

As chromium is the principal toxic contaminant of concern, it is important to note the controversy over the chromite ore leaching tests. As reported in the EIS, section 4.3 (p.22), leaching tests of raw materials (coal, silica and chromites) were conducted with seawater and with simulated rainwater (pH 5.8, rising to 7.5 during the test). High levels of removal of Chromium III were found for

Indonesian concentrate, in the amount of 0.140 mg per Litre^{-1}. A Canadian concentrate gave 0.0006 mg L^{-1}. (The permissable Special Waste leachability for Chromium is 0.1 mg L^{-1}). The high Indonesian levels persisted on re-testing.

Notably, systematic sub-sampling protocols were not used on the drums of chromite as received. The "Special Waste Extraction Procedure" (SWEP) requires 0.5 N acetic acid as leaching solution. It was abandoned on the basis of the potential for acetic acid to reduce Chromium VI in the leachate. However, the margin of safety for heavy metals, such as cadmium, copper, lead, intended by using an acidic leaching solution (SWEP procedure) was then lost in the procedure used. Clearly standard SWEP tests must be done on the chromite ore (and, by inference, on the slag to be stockpiled).

It has been argued that the 0.14 mg L^{-1} of Chromium III represented "colloidal" material. A very fine 0.45 um (micrometer) filter is used on the leachate before analysis. The Panel notes that is just such fine material that concerns Dr. Nriagu of Environment Canada. He suggests it may, even if a solid, be potentially bioavailable or subject to solubilization.

The Panel must assume a degree of uncertainty exists as to the leachability of chromite (as fine material, less than 0.45 um). Without further SWEP tests using 0.5 N acetic acid, the accepted levels of other metals that might be leached are also not established. This matter is also addressed in Section 5 (Monitoring) and in Section 2.1 (Raw Materials).

Sediment and Water Quality Data

The proponent established two foreshore sediment sampling stations were established, "Sed 2" and "Sed 3". Analytical data is reported in Table 3.14 of the EIS (p.3-36). Chromium (total) values were 28.4 and 36.3 mg kg^{-1}, which agrees favourably with Environment Canada data. Aquatic sediments, as collected from the site ("Sed 1") 44.0 mg kg^{-1} and at the Ferry Terminal (Sed 4) 66.0 mg kg^{-1}, were higher. Freshwater quality analyses (EIS, Table 3.16, pp. 3-51 and 3-52) indicate Chromium levels of 1 to 2 ug L^{-1} or less at five stations.

The proponent conducted a sampling program for heavy metals in water in Hardy Bay at two stations. Chromium total is reported as under 0.2 ug L^{-1}. (Refer to EIS, Tables 3.27, 3.28, and 3.29 for complete seawater parameterization; file 183-Pro.17).

Sediment Standards

Tables 3-D and 3-E summarize important sediment and associated water quality objectives. Background information is provided in Appendix M. Of particular note is the 60 mg kg^{-1} total chromium sediment value, established recently for Burrard Inlet by the B.C. Ministry of Environment. The water quality values are 2 ug L^{-1} for the tributaries to Burrard Inlet, clearly a freshwater value.

A succession of values are quoted for different sections of the Burrard Inlet and the values here are cited for the First to Second Narrows portion of the inlet, although they are often more widely applicable.

Based on the evidence considered and the objective of avoiding significant environmental impact, the Panel recommends that the sediment maximum Chromium Total concentration should be 60 mg/kg dry weight, and that the water quality standard in Hardy Bay, freshwater streams and rivers affected by the plant be maintained at 2 ug L^{-1} chromium, or baseline levels, whichever is the higher.

Other trace metal concentrations shown in Tables 3-D and 3-E represent appropriate indications of current Ministry Objectives.

TABLE 3-D

SEDIMENT TRACE METAL VALUES
(ppm or mg kg^{-1} dry weight)

	Puget Sound Marine Sediment		BC MoE Objectives	Hardy Bay
	A Quality Standard	B Minimum Clean-up	Burrard Inlet (Recommendation)	(Environment Canada)
Chromium	260	270	60	21.7 - 43
Arsenic	57	93	20	under 8.0
Cadmium	5.1	6.7	1.0	0.2 - 1.6
Copper	390	390	100	14 - 43
Lead	450	530	30	3.3 - 8.7
Mercury	0.41	0.59	0.15	0.008 to 0.15
Silver	6.1	6.1	—	—
Zinc	410	960	150	45 - 88.6

TABLE 3-E

SELECTED TRACE ELEMENT PROVISIONAL WATER QUALITY OBJECTIVES FOR BURRARD INLET

Substance	First to Second Narrows (tidal) Per Litre	Tributaries (freshwater)
Chromium	(not given)	2 ug
Arsenic	10 ug (max)	(not given)
Cadmium	9 ug (av); 43 ug (max)	0.2 ug
Copper	2 ug (av); 3 ug (max)	2 ug average
Lead	≤2 ug (av); 140 ug (max)	(not given)
Mercury	0.02 ug (av); 2.0 ug (max)	0.1 ug max.
Zinc	0.086 mg (av); 0.095 mg (max)	0.015 mg max
Cyanide	1 ug (weak acid dissociable)	(not given)

Pending publication of new comprehensive British Columbia "Receiving Water Quality" guidelines, the Panel recommends that ambient water parameters for trace elements in the fresh and marine waters in the vicinity of the site should be maintained at baseline levels or at the values 3-E, whichever are lower. Furthermore, the Panel recommends that the sediment values "BC MoE Objectives" in Table 3-D be adopted.

The Panel recognizes that these levels represent a stringent standard. The present site near a specialized and highly valued estuarine ecosystem, must be afforded the most current and conservative levels of protection that are accepted, based on exhaustive studies and analysis by agencies and experts familiar with this region of the Pacific coastal zone.

Deposition to Aquatic Sediments

Assessing the impact on fresh and saltwater bodies from deposition is difficult based on available information, as explained in Section 3.3.3.

Of particular importance are the Quatse River drainage and Hardy Bay where impacts on salmon adults, spawn and fry must be avoided. Appendix K provides background information regarding the toxicity of chromium to marine and aquatic organisms.

It is possible to construct "worst case scenarios" by assuming:

(1) Surface runoff carries all particulate deposited on the river drainage into the water.

(2) Total dissolution and retention of the particulate flux across the water surface.

(3) Both wet and dry deposition.

Consultants for the proponent presented such scenarios (file 403-Pro.62; file 335-Pro.33, p.5.47) for both the Quatse River and Hardy Bay, assuming deposition in the upper 50 meters of the bay and no tidal action. The consultants compared the values for chromium and other trace elements (including arsenic, using EIS Addendum stack emissions) with the U.S. EPA water guidelines, date unspecified (file 403-Pro.62). The values (shown below) for chromium from these "guidelines" were quite liberal and in sharp contrast with the values for protection of aquatic communities.

	Marine (ug L^{-1})	Freshwater (ug L^{-1})
Cr Total	50	51.0
Cr VI	50	11.0

As noted earlier, the B.C. Ministry of Environment value to protect aquatic communities is 2 ug L^{-1}. The proponent's projections exceed these values after one year (total concentration of 4 ug L^{-1}, with a background concentration of 1.2 ug L^{-1}).

Predicting assimilation in the system over the surface to sediment pathway is uncertain. The calculation, however, suggests that a margin of protection related to the 2 ug L^{-1} standard is not clearly present at the chromium emission limits proposed by the proponent. The lower ambient air levels of 0.002-0.05 ug/m^3 for chromium suggested in Section 3.2 may serve to provide additional assurance against impact. The Panel does note (EIS Addendum, p.5-40) that the calculation had conditions as follows:

> "a uniform ambient air concentration of 1.2 ug m^{-3} over the Quatse River Basin was assumed. This results in a total annual deposition of 3.4 mg m^{-2} y^{-1}."

Once again, the need to collate and summarize air modelling and projected deposition, including model calculations is clear.

It is recommended that approval of this project be conditional on satisfactory analysis, based on final air dispersion modelling, to demonstrate that depositional impacts to water and sediments are within the levels given in Tables 3-D and 3-E.

Assessment of Sediment Contamination

Uncertainties in projected water and sediment concentrations of total chromium outlined in the preceding sections are of concern to the Panel. The availability of the chromium in the water column and in the sediment will be a critical factor in regard to ensuring the conservation of the area's valuable marine and fishery resources.

The Panel observes that levels of chromium in sediment corresponding to an adverse effects level (or AET) are very much higher (270 mg kg^{-1}) than the uncertainty that exists between Dr. Caton

and the proponent's consultants, based on soil calculations. In other words, based on the limited evidence available, there does not appear to be a significant risk.

The Panel has considered the degree of protection that is "built in" to the 2 ug L^{-1} water value, and the likelihood that the assimilation in the water column by all pathways will be a small percentage of the particulate flux. As a result, the Panel believes that, provided the public protection values of 0.002 and 0.05 ug m^{-3} are maintained in ambient air, impacts on the critically important commercial and native fisheries will be below the detectable "adverse effects level".

The sewage outfall of the district municipality of Port Hardy has resulted in the closure of the previously important butter clam fishery on the west side of Hardy Bay. No mitigation or reclamation programs have been instituted. The total loading in Hardy Bay is determined currently by such outfalls and the port boat activity.

Therefore, the conclusion of "no adverse impact" (as suggested above) must be qualified by a monitoring program that must include the levels at which corrective action are required to be taken, as well as commitments to the overriding precedence of corrective action, including shut down of facilities and curtailment of production.

The Panel also emphasizes the importance of further detailed studies on the availability and toxicity of priority list pollutants such as chromium. In particular, the Chromium Task Force under the Canadian Hazardous Substances Program should provide clarification of the hazards presented to biota in these aquatic environments by chromium deposition.

3.5 TERRESTRIAL IMPACT ASSESSMENT

Terrestrial environment issues include (1) the physical effect of the construction and imposition of the plant and associated facilities on the landscape, (2) the impact on soil by deposition of acidic and particulate material from the air, (3) the impact of air emissions on local vegetation, and (4) the handling of solid wastes (including slag).

3.5.1 Physical Effects

The physical effects of constructing and imposing the plant on the landscape can be assessed based on information contained in the EIS and various other written and oral submissions made to the Panel.

The site is presently undisturbed and forested. The creation of the plant and ancillary facilities, including the hydroelectric power line, will unavoidably alter this present condition. While there is a recreational trail of local significance, the Panel was presented with little evidence of active use. The one notable use that would be displaced by this plant is part of a trapline which extends through the area.

According to the provincial Ministry of Environment, wildlife is not particularly abundant in the area. Nor are there concentrations of special or outstanding habitats or populations. It is a small site wherein may be found the typical variety of mammal, bird and other types of animals characteristic of this type of forest regime. Wildlife in the area (particularly marten) is said to sustain part of the trapline which is operated by a member of the local native community. Raptors, especially bald eagle, nest in the general area. Provision for protection of roosting and nesting trees was referred to in the EIS. For other species of large animals (primarily deer and elk) habitat conditions are considered to be inferior. Provided that the specifications of the Ministry of Environment (file 359-Govt.37) are followed, particularly with regard to avoidance of eagle nesting sites, the impacts upon wildlife are not considered to be significant.

Some archaeological resources, notably middens, have been located on the site. The proponent has adjusted plant configuration so as to avoid disturbance of these, in accordance with the policy of the Province's Heritage Conservation Branch of the Ministry of Municipal Affairs, Recreation and

Culture. Therefore the physical protection of these sites is not considered to be an issue of concern. However, sufficient care must be taken during the construction phase, with involvement of the Kwakiutl, to ensure that these sites are not disturbed. These middens are central to the cultural significance of the site, and it is recognized that this significance extends beyond the specific locations of the middens; this matter is further discussed in Section 4.5 (Native Concerns).

During construction, there could be a siltation problem in the small streams on the site and in the vicinity of the hydroelectric corridor. These could be avoided if appropriate precautions are taken in road building, clearing and construction.

The Panel notes that the EIS does not provide hydrology information regarding the permeability of the substrata or details of the water table level. Potential effects from either the raw materials or slag storage areas are therefore difficult to predict.

It is recommended that the proponent be required to provide hydrological data to the Ministry of Environment, and that this data adequately demonstrate that water table penetration and contamination will be avoided through appropriate design of storage facilities.

As stated at the outset of this environmental impact review, the small physical dimensions of the project tends to localize physical habitat loss in the terrestrial environment. In comparison to other industry in the region, particularly the forest industry, the impacts of this proposed plant on the terrestrial environment would be minor.

As the plant would be compact by most comparisons and as Sherwood has indicated a desire to retain as much of the natural forest cover as possible, the Panel concludes that its relative physical impact would be small. However, it is noted that the character of this forested area, as perceived by local residents, would radically change from an "unmodified" condition to a "man-modified" landscape.

It is recommended that, to the greatest extent possible, the plant design and construction must retain the natural vegetation of the site. This should include the retention of a shoreline buffer of vegetation and sufficient tree retention elsewhere so as to screen the plant from view as much as possible.

3.5.2 Air Emissions Impact on Land

Soil Depositions of Acidic and Particulate Materials

This is potentially an important issue. The deposition of air emissions is cumulative and may be spread over a very large area, depending on wind patterns and dispersion effects.

Apart from the chromium carried by the particulate, the dust loading relative to the ambient levels in the area will not be significant. Of more concern is any incremental addition of acid deposition (measured as sulphate). Such deposition is derived from NOx and SOx oxidation to the nitrate and sulphate. (**Refer to Appendices H, I and J**). The potential for this impact is addressed earlier in this report, in Section 3.3 (Air Emissions).

As stated in Section 3.3.3, it is necessary that the proponent complete a full review and revision of the data on this subject.

Mindful of the uncertainties in acid gases, trace metal and chromium deposition on land (Section 3.3.3), the Panel again compares the relative magnitude of the effects and the importance of terrestrial resources impacted. Provided the proponent fulfils the commitment to use only low sulphur coal, and using the new values of sulphur emissions, the total output of SO_2 is only about 64 tonnes/year. This is a modest value in comparison to the average conventional pulp mill that emits several thousand tonnes per year.

The acid sensitivity of the soils in the Port Hardy area, the relatively limited data base on local deposition, and the uncertainty as to contribution from sea spray sulphate to background levels, are factors that suggest that the Ministry of Environment whould further monitor acid deposition in this area.

Effect of Air Emissions on Vegetation

Specific NOx and SOx effects on trees and on the vegetation arise from the emissions at moderate stack heights into the foliage. At the present site, concern has been expressed regarding conifers to the east of the stack. It appears that the higher terrain to the east represents some potential for direct impact upon vegetation at the height of the canopy.

The Panel recommends stack location should be carefully assessed in order to mitigate possible impacts to nearby vegetation.

3.5.3 Solid Waste Handling

Slag

An area of concern has arisen for terrestrial impacts through the decision to stock pile slag for possible conversion into Sherglas at a later time. Mr. Wooding, on behalf of Sherwood, made the casual remark while testifying at the hearings, that:

> "..there's these steep areas over here where we can hide a few thousand tonnes of it until we can afford to put the Sherglas plant in." (Transcript, p.2646).

Mr. Wooding also pledged that this slag would not be leachable, but that it would be subjected to leach testing before storing it.

The Panel recommends that the Chromium VI special waste leachability figure of 0.1 mg L^{-1} (B.C. MoE) be regarded as total soluble chromium, consistent with the analysis of the CrIII/CrVI speciation question rendered in this report.

While it is likely that the slag may well be judged to be nonleachable, as determined by appropriate testing, the proponent has not offered a method of disposal should these tests indicate the contrary.

The Panel recommends that leachate tests should be performed on a simulated sample of the slag before the waste permits are issued for the plant. If it is determined that the slag exceeds leachability criteria, so as to be classified as "Special Waste", then it should be a condition of permitting that the Ministry of Environment be provided with and approve a plan to handle this material in a manner that does not pose a hazard.

It is also recommended that regular leachate tests be conducted on slag produced during the operation of the plant.

It is further recommended that the possibility of significant entry into the water table and hence the terrestrial environment must be avoided by using "hardened" sites for slag storage. This includes containment by berming and peripheral runoff collection systems.

Other Solid Wastes

In fact, the plant will produce a range of other reject materials requiring disposal:

(1) water treatment sludges and filtrates
(2) used baghouse fabrics
(3) reject activated carbon
(4) sodium and potassium oxides
(5) baghouse dust (Special Waste).

All of these materials involve direct contact with the process flows, and therefore can be expected to be contaminated. Based on its observations of a conventional stainless steel plant and a ferrosilicon smelter, and having there observed the fugitive dust and storage problems for such materials, the Panel is concerned about their proper handling and disposal.

These issues are not completely addressed in the proponent's documentation, and therefore the following questions must be adequately addressed as a condition for permitting the plant to operate:

(1) Does any sampling method exist for certifying that these materials are safe for local regional district landfill disposal?

(2) What waste reduction and re-use options can be employed?

(3) Is there capacity and environmentally secure locations at the local landfill such that they can be disposed of there over the long term?

(4) Has provision been made for covered on-site storage pending shipment of these materials?

(5) What provision is there for handling of fine particle dust (from the baghouse) when it is a "special waste" and must be removed from the system due to elevated levels of undesirable trace elements?

It is not logical to enforce BACT provisions for stack particulate if chromium-bearing dust or sludges are being distributed throughout the local environment in an uncontrolled, unmonitored manner.

It is recommended that facilities for handling such solid wastes and for safe storage of these materials on site must be addressed by the B.C. Ministry of Environment and by the proponent.

3.6 RECEIVING ENVIRONMENT: OVERALL CONCLUSIONS AND RECOMMENDATION

Based upon the foregoing sections of this report, and having considered the environmental impact evidence before it, the Panel makes the following overall conclusions:

(1) Provided that carefully prescribed terms and conditions are adhered to in permitting and in enforcement, it is concluded that the Sherwood smelter/refiner and Sherglas production facilities, based on the annual production levels reviewed in this report, can be constructed and operated in British Columbia in a manner that will have manageable and acceptably low levels of environmental impact.

(2) In view of the highly valued and potentially sensitive marine and fishery resources of Hardy Bay and the Quatse River (and estuary), it is concluded that, from an environmental perspective, the site presently under consideration (near Bear Cove) is not ideally suited to the establishment of the Sherwood plant. Included in this conclusion are the many developmental elements of the plant design which, together, pose a substantial level of risk to this particularly sensitive area.

Therefore, in the light of these conclusions, the Panel concludes that the proponent and government may choose to locate the plant at an alternative, less sensitive site. However:

The Panel recommends that if government determines that the proponent may proceed with the Bear Cove site, then all of the foregoing recommendations and the recommended monitoring program, as outlined in Section 5, should be applied.

It is noted that these conditions could be adapted to and should apply to any other selected site, where they might more easily be achieved.

4.0 SOCIAL ISSUES

The determination of social impacts and benefits is complex with regard to any endeavour. This is certainly true with regard to this project. There are a great many interdependent issues: for example, economic costs and benefits, subsidies, public perceptions, confidence in the proponent, confidence in government, viability of the plant, alternative economic prospects for the region, public opinion, and so forth. The Panel has received a great deal of information and testimony on such issues and has endeavoured to evaluate and weigh all of this material, both fact and opinion.

As examples, among the many factors and issues that the Panel has had to carefully consider, are the following: the proposed closure of the Utah Mine, the impromtu opinion poll conducted in Sointula, the introduction of a smelter into the traditional logging, fishing and mining communities of the North Island region, the net value of the jobs to be created, and the possible effect upon the outer communities such as Alert Bay, Sointula and Port McNeill.

The Panel's evaluation of social issues is subdivided into six categories: (1) project viability; (2) public confidence; (3) economic benefits; (4) public investment; (5) quality of life; and (6) native concerns. We have reached conclusions in each of these.

4.1 PROJECT FEASIBILITY

The concern has been expressed that if, sometime after construction, the plant cannot operate due to technical, market or environmental factors, then none of the benefits will accrue to the communities, yet some of the costs will already have been borne. Therefore, the general question of project feasibility is a social issue.

This report has earlier considered the technical feasibility and the environmental impact of the plant. The Panel has concluded that within the parameters specified by this report, the project is technically feasible.

However, viability of the project with respect to markets requires further consideration. Evidence has been given that low carbon ferrochromium has not been a major product in the world relative to high carbon ferrochromium. Apparently this is because, in the manufacture of stainless steel, the systems in wide usage are designed to utilize high carbon ferrochromium rather than the more expensive low carbon ferrochromium.

The evidence of the proponent is that the quality of product to be produced would be significantly greater than competing products and would therefore readily capture a market directed toward the manufacture of materials that require the highest quality of alloys. Certainly the existence of private financial support (Elders Resources Finance Inc.) and the existence of "take or pay" contracts for 25,000 tonnes per year for 10 years (file 52-Pro.5, p.12) are evidence that the external business world has confidence in the market viability of this project.

Throughout this review, the Panel has heard both expert and non-expert opinion on both sides of the issue of the project's economic viability. It is the view of the Panel that this matter cannot be answered with complete assurance for any commercial project. There are always levels of business risk, regardless of the confidence of the proponents.

Conclusion

Based on the evidence before us and the consideration of probabilities, we conclude that the proponent has endeavoured to minimize the business risk. From this we conclude that economic viability, although not a certainty, has been reasonably established.

4.2 PUBLIC CONFIDENCE

The issue of public confidence in this project has three dimensions: confidence in the initial decision making process for government support of this project; confidence in the proponent to construct and operate the plant to specifications; and confidence in the ability to monitor and regulate the environmental performance of this plant.

One of the values of a full environmental review is that through an open and thorough examination of evidence, it is possible for mistrust of the decisions of government or of a proponent and a project to be illuminated and possibly surmounted, with provisions made to give the public confidence in the future.

Initial Commitment Decision

There remains considerable public scepticism surrounding the basis for government's initial support of this project. In October 1988, Rescan Environmental Services was contracted by the B.C. Ministry of Environment to provide a preliminary environmental assessment of the Sherwood project at the proposed Bamberton site on southern Vancouver Island. On the basis of this report and other background studies prepared on behalf of the provincial and federal governments, both governments were prepared to commit a total of $9.75 million in public financing at special terms as a capital incentive package. Due to public concerns, the regional district place constraints on rezoning of the subject property and the project was then proposed for Jack Point, at Nanaimo. A major criticism from the public has been that both senior levels of government appeared prepared to support the project despite the lack of thorough environmental assessment and the lack of a public review process.

To this end, the proponent received approval-in-principle in the Spring of 1989. In addition to the loan of capital, the provincial government required B.C. Hydro to offer the proponent electricity at a special low rate not available to other industrial customers (file 293-Govt.26). This strong government support substantially contributed to public scepticism (eg. Fields: file 549-PS.234).

At the time when the third potential location, near Bear Cove near Port Hardy, was announced, the project was enthusiastically supported by the municipal council of Port Hardy as well as by that municipality's Economic Development Committee. It appears that neither of those bodies had conducted a survey of public opinion in any formal sense, and it appears that major local interest, such as the native peoples and the fishermen, were not included in any committee deliberations on the subject. In a small community without a history of this kind of industry, it is not surprising that this decision process raised the concerns and criticisms of many residents.

The site identification process at Port Hardy remains somewhat of a mystery to this Panel. Apparently a number of sites were contemplated in an informal manner, and the proponent

determined that the Bear Cove site was preferable. The criteria used to determine site suitability were poorly documented and this has added to public scepticism about the project. It appears that no provincial agency, federal agency, or local government authority took sufficient care to ensure that the proponent was fully aware of the existence of the "Douglas Treaty" and native land claim with respect to the selected site.

Subsequently, the proponent did become aware of the strong native concerns and claims to have tried to open a dialogue with them. For whatever reason, this dialogue did not occur. All of these factors have contributed to significant, although far from universal, public anxiety over the project.

Confidence in the Proponent

A large number of witnesses before the Panel expressed considerable scepticism about the promises of industry. In this instance, scepticism was enhanced by the contrast between the history of chromium industries and the claims of the proponent. It was further heightened by the lack of substantial information that the proponent was prepared to supply. Not until several months into this particular review, long after the project was initially proposed, did the proponent commence supplying detailed technical information that could be examined. The sudden change of proposed sites from Bamberton to Jack Point to Port Hardy fostered suspicions, whether rightly or wrongly, among the media and the public that the proponent wished to avoid substantial external analysis of its project.

Throughout this review process, the design of the plant has changed in significant ways. Largely these have been refinements needed to meet environmental objectives, however they have also reinforced the suspicions of critics that the proponent has been engineering a pilot plant rather than building from an existing prototype. Some changes in design -- such as the proposal that a temporary docking facility could be used and the late announcement that mineral fibre would not initially be produced -- indicate the uncertain financial resources of the proponent. The latter change of plans was revealed only toward the end of this review process.

Public confidence also has been affected by statements made and actions taken by Sherwood's president, Mr. J. Wooding. There seems to have been a tendency to mislead through exaggeration. For example, his initial statement that government would collect some $64 million in tax revenues was, in fact, exaggerated by a factor of 100%. His account of what happened in the State of Oregon,

with regard to Sherwood's proposal there, does not fully accord with correspondence between the proponent and that government.

Credibility has also been affected by signficant absences of important technical information and analyses, particularly in the early months of this review. For example, Sherwood had continually stated that it would not be possible for the process to produce Chromium VI, which is the carcinogenic form of chromium. Expert evidence later revealed that it is possible for Chromium VI to be produced in the waste gas stream from the refiner.

Notwithstanding the technical and professional credentials of Sherwood officials, including Mr. Wooding, such matters as described here have undermined the proponent's credibility with the public during this review process. The Panel observes the proponent has had a tendency to offer a self-edited version of facts and evidence. In addition to lowering public confidence, this practice has complicated and frustrated the Panel's task of assessing the social implications of the project. However, the Panel has attempted to objectively assess the project on its own merits, rather than the conduct of the proponent.

Government Regulators

From the outset of this review, the public has expressed considerable doubt that the responsible federal and provincial government authorities are able to effectively monitor and regulate any industrial operation. The public fear is that once the plant is built and operating, the monitoring and the regulation will be relaxed to allow the plant to continue to operate even if emissions are higher than permits specify.

Much of this cynicism is based on the experience of British Columbians with pulp mills. Ministry of Environment officials admitted before the Panel that they have not enjoyed a track record of rigorous monitoring and vigorous enforcement of regulations and permits. (Transcript, p. 813-814). These officials indicated that the regulations would henceforth be applied with a higher level of vigilance.

Both at our technical and community hearings, there was expressed a deep mistrust of government and industry to live up to their promises with regard to environmental impact and controls. Repeatedly, the Panel was told of the pulp mills and other industrial projects where both industry

and government gave assurances that they would be environmentally acceptable, that there would be no problems from emissions, effluents, and so forth, and that if problems did emerge, corrective action, including shut down of operations, would occur. The public is aware that in numerous instances such promises have not been kept, and that on many occasions substantial environmental damage has occurred without significant penalties (substantial fines or shut downs) being imposed. In this context, it is understantable that many people of the North Island region are suspicious of this particular project and of both the federal and provincial governments, who, it is popularly perceived, have sided with industry rather than protected longer term public and environmental interests.

Public concern about government's monitoring and regulatory capability extends to considerations of the risk of and precautions in the event of major plant failure. The technology and environmental analyses of this report is such that plant failure does not seem a substantial issue, regardless of popular perceptions. However, there are certain risks inherent in the development of any such industrial project, where there is a strong dependence upon technology and the workforce to build and operate the plant in accordance with specifications.

The Panel is satisfied that emergency shutdown procedures will be included in the final design. However this cannot overcome the public perception of long term accumulation of toxic materials in their environment such that their environment, their livelihoods, and even their health might be affected. As Dr. Shaffer notes:

> "There is a cost to uncertainty. In economic terms, people generally have to be compensated or there have to be offsetting benefits for people to be willing to accept the introduction of risks or uncertainty in their community or lives." (file 352-Pan/Ex.22, p.22).

As part of this problem, the public expects that consideration must be given from the outset as to the environmental and financial implications for the public if the plant should, for whatever reason, be shut down for the long term. Based on experiences of the past, an abandoned plant could become a public liability. Storage and handling of stockpiled materials then becomes an issue. The public has a right to be concerned with such issues, such that the appropriate precautions can be taken.

It is particularly notable that the accumulating fund recommended by the proponent, to a maximum of $1 million, is unlikely to be an adequate measure in respect of our concerns for these possible scenarios. The Ministry of Environment notes (Transcript, p.811-812) that it commonly

contemplates imposing some form of financial security or bonding on industrial operations, as an insurance to cover clean-up costs in the event the operation ceases for financial reasons.

Dr. Shaffer points out that, because it is the proponent's claim that there would be not adverse environmental or health effects, then "the proponent, and not the affected communities, should bear the risk and responsibility of that claim" (file 352, p.30).

Conclusion and Recommendations

In the event that this project proceeds, any net social benefit could be considerable impaired if the public confidence in both the proponent and the government regulators remains at current low levels. The Panel hopes that these parties will endeavour to raise public confidence.

In consideration of enhancing public confidence, the Panel recommends that the B.C. Ministry of Environment be closely involved in all aspects of the establishment and monitoring of the standards which this report recommends for this project.

In addition, we recommend that the British Columbia government ensure that the Ministry of Environment has available the resources and personnel to fulfil the specific tasks which have been referred to them under the Waste Management Act and the Environment Management Act.

It is further recommended that the monitoring program recommended by this Panel be coordinated and supervised by the Ministry of Environment, that the proponent bear the costs of this monitoring program, and that there be full, open and timely supply of monitoring information to the public, through a locally-based committee of interest groups. The concept of such a committee was agreed to by the proponent at the hearings.

The Panel recommends that the Ministry of Environment coordinate the formation of this locally based monitoring committee. It should be funded through the proponent's permit fees or a similar arrangement made for proponent sponsorship.

It is further recommended that participation in this monitoring committee should include the principal government agencies, as well as representatives from local organizations (including native

groups) concerned with this issue. These members of the public would serve on a voluntary basis as a community service.

Finally, it is recommended that, as a condition of approval, the proponent be required to post a bond or other such security (acceptable to the Ministry of Environment) of a magnitude sufficient to provide for any clean-up operations that can be anticipated in a "worst case scenario" and to provide compensation to parties who might be adversely effected. The magnitude of this security should be determined by the Ministry of Environment. It is noted that the possible need for compensation capability from the security can be reduced in significance by the effectiveness of the monitoring and enforcement program.

4.3 ECONOMIC BENEFITS

The evidence regarding principal economic benefits may be categorized as: (1) employment; (2) local tax base; (3) income tax revenues; and (4) industrial diversification.

Employment

The number of jobs that this plant would generate has been debated since the origin of the proposal. Initially a figure of 400 was suggested by the proponent, but this was later revised to 250, and then finally to 130 for the phase under consideration in this review.

Concern over the economic future of the Port Hardy area was a major theme expressed to the Panel. Recently, a nearby military communications base has been closed and announcements have been made about the limited lifespan (possibly only a few years) of one of the region's largest employers, Utah Mines. As Dr. Shaffer identifies:

> "Port Hardy officials are concerned that the closure of the mine, combined with the closure of Holberg (Canadian Forces Base), could significantly reduce the population in the District and particularly in Port Hardy." (file 352, p.5)

Concern over the threatened closure of the nearby Utah Mine contributed to the interest of the Port Hardy municipal council and others in attracting the ferrochromium smelter. This mine, as do all mines, will eventually close, but there has been speculation for many years as to when this might

occur. Most recently, it has been postulated that unless new ore reserves are discovered or unless remaining reserves are made more profitable by a change in market prices, then the mine can be expected to be phased out in the mid-1990's. The bottom line is that no one can be certain when this mine would shut down, but when it does this will have a serious economic impact on Port Hardy and some effect on the general economic vitality of the region.

This Panel has not been assigned the task of assessing the potential of this mine or its contribution to the local economy. However, because of the local interest in attracting replacement jobs through the ferrochromium project, it is appropriate to comment on this situation. The Panel is inclined to support the assertion by Dr. Shaffer (file 352-Pan/Ex.22) that differences in timing and job types are such that it is unlikely that Sherwood's ferrochromium project would directly offset any significant unemployment caused by phasing out of the mine. Dr. Shaffer also notes that the statistical evidence demonstrates that unemployed, skilled workers tend to leave the region in search of alternative work, rather than remain unemployed within the region. It is also noteworthy that the employment level at the proposed smelter would be less than a fourth of the workforce at the mine.

Of the projected 130 jobs at the proposed smelter, the proponent has stated that local residents will be entitled to apply for these. Of course, it is apparent that some number less than 130 could be initially drawn from the local area, due to the lack of the necessary specific skills. The proponent's information regarding jobs and employment policy has not been clear, but was assisted by the filing of a document in late October (file 537-Pro.89). This document shows that the plan is to attain the full complement of 130 employees some 42 months from commencement of the project.

There was considerable debate over how many of these jobs would likely be filled by current residents of the area. Dr. Shaffer pointed out that there tends to be a lack of suitably skilled unemployed workers in region:

> "... there is little reason to expect 50% of the workforce to be supplied locally." (file 352, p.16)

Nevertheless, all jobs created by such a plant would result in salaries being paid in the local area, which would then help support the local service industry and the local administrative infrastructure. Regardless of where the employees might originate from, ultimately they would be residents of the local area and this would benefit the local economy. Shaffer estimated that total salaries and

benefits could be about $4.8 million per year. (Ibid.,p.16). Also, Sherwood estimated that the operation of the plant would involve a further 65 workers.

In addition to employment from operations, the construction of the plant would result in local hiring. Sherwood estimated that the construction would involve about 85 person years of employment, with a total labour force income of roughly $3.7 million over the entire construction period. Also, direct local employment from construction would involve an additional 70-100 workers (Ibid. p.17).

This additional direct and indirect employment, regardless of the accuracy of the figures, would clearly be an economic advantage for Port Hardy and this is particularly important to the merchants and other residents who are dependent upon the level of general economic activity. Sherwood estimated that during construction some $750,000 of goods and services would be supplied locally, and part of a further $2.15 million of goods and services would be supplied locally. Once in operation, the plant would acquire up to about $1.675 million annually of goods and services from the region.(Ibid., p.18). Furthermore, it is noted that Port Hardy's economic vitality is of some importance to the surrounding region, as it is the largest centre in the area.

Local Tax Base

The District Municipality of Port Hardy, the Economic Development Committee of the municipality, and the Just People group made the argument that, along with jobs, this project is necessary in order to assist the support of local administrative infrastructure.

Dr. Shaffer's evidence in this regard was that this could well be among the most important contributions of the plant to the local area. In 1989 for instance, Utah Mines paid some $980,000 in local taxes. This was 26% of the local tax base. (Ibid., p.10). If the mine is phased out, then the local tax revenues from the Sherwood plant would be quite important to the municipality, possibly exceeding the estimate by municipal officials of $450,000 annually.(Ibid., p.21). If the mine does not close, these revenues would not be as critical, although they would remain important. It must be emphasized that such benefit only accrues to the municipality if the plant is built within the boundaries of the municipality. Notably, although the site of Utah Mines is considerably distant from the municipality, that site is in fact an "island" of the municipal territory.

With regard to local tax revenues, the evidence is that while this is a positive matter for Port Hardy itself, there would be little or no such benefit to the general region. This is a concern to the native peoples and to residents of other communities who feel they have little to gain from, and much at risk from such a project.

Senior Government Revenues

If this plant was to be operated, there would be two sources of income tax revenue for senior governments, the operating company and the employees. The former source will only pay income tax based upon profit levels, and these are subject to unpredictable market conditions and the uncertainties associated with any plant commissioning. It is also noted that both senior governments derive sales tax revenues as well.

Little reliable information was provided to this panel with respect of the value of these revenues. The proponent claimed that its income taxes in the first six years of operation would be $64 million dollars and that its total taxes over the life of the project could exceed $200 million. As Shaffer notes:

> "Neither Sherwood nor the government has released any financial and market data that would support this claim, though government officials acknowledged it was probably too high....In short, on the basis of currently available information, income tax revenues of the magnitude suggested by Sherwood would have to be considered highly speculative." (file 352, p.27).

At the hearings, Mr. Wooding admitted that he had used figures which were inflated for the purpose of enhancing the support of the project. If the project is a success at manufacturing a product at below present market costs and can sell it at a profit, then the governments of Canada and British Columbia may expect to receive income tax revenue. The certainty of taxation revenue, the timing of the return of such revenues, and their probable magnitude cannot be assessed at this time. Beyond corporate taxation, the governments will derive tax revenues from the salaries of employees.

Industrial Diversification

There is a general belief that added economic diversity represents an economic benefit in terms of the added resilience it brings. Based upon the testimony of Mr. Heartwell of the office of the

federal Western Economic Diversification Fund, this would appear to be the fundamental doctrine in support of the loans that both that office and the provincial government have been prepared to provide to the proponent. Mr. Heartwell testified that:

> "...our view is to try to help diversify the economy by providing assistance to businesses that we believe will make a long-term contribution to the economy, and are introducing new technologies that we hope will lead to further developments of projects."

The region traditionally has depended upon forestry and fishing as the mainstays of the economy. In the last two decades, the Utah Mine has been operating and also contributing substantially to the economy.

Tourism plays a lesser, but growing role. There are many residents of the region who express support for the expansion of the tourism industry based upon the natural scenery, wilderness values, sport fishing, and other recreational opportunities. During this review, the Panel received letters and heard concerns voiced that the introduction of heavy industry to this region, as for example the proposed ferrochromium smelter, could either adversely impact the quality of the natural environment that attracted tourists, or could lessen the interest of tourists in visiting the area.

A similar concern has been expressed with regard to the fish farm (North Fjord Fish Farms Ltd.) which has been established immediately north of the proposed Sherwood site.

Within this context, there would appear to be a divided argument for introducing industrial diversity into the region. It is important that a new activity does not diminish the effectiveness of or the opportunities for the existing or future economic prospects of the region.

<u>Conclusions and Recommendation</u>

The Panel concludes that the plant would generate additional employment in the region and this would be an economic and social benefit generally, regardless of whether the Utah Mine closes.

The Panel concludes that, without an affirmative hiring policy that favours natives, this plant is unlikely to result in the creation of employment opportunities that would assist in increasing the employment rate among the native communities.

It is recommended that the proponent take every reasonable effort to hire as many as possible of its employees from both the native and non-native communities of the region.

It is concluded that the District of Port Hardy would benefit from the property tax revenues generated from this plant, but that other communities in the region would not obtain this benefit.

If this plant is successful, the income, sales corporate tax revenues obtained by the federal and provincial governments would constitute an important economic benefit.

This plant could benefit the region in terms of economic diversification, however this benefit is only of value if other economic opportunities, such as tourism, are not foregone or displaced due to negative environmental impacts.

Considering that almost all of the raw materials will be imported, all of the finished products will be exported and the ownership and, therefore, profits of the project will flow to its American and Australian owners, the jobs, tax revenue and economic diversification become the principal social benefits to the region.

4.4 PUBLIC INVESTMENT

Hydroelectric Rates

The proponent has been offered a discounted hydroelectric rate of $0.02 per kilowatt hour, as opposed to the normal rate of $0.03 per kilowatt hour. This matter has raised many questions and many concerns. Firstly, this incentive does not appear to be consistent with the much-publicized B.C. Hydro philosophy of encouraging energy conservation. On the other hand, it is quite clear from the Order-in-Council issued by the provincial Cabinet (file 293-Govt.26) that B.C. Hydro was directed to offer this discounted rate. According to testimony from Mr. Loewen of B.C. Hydro, the crown corporation has no choice but to take direction from government.

Interestingly, the Order-in-Council regarding the special power rate offered to Sherwood specified the Nanaimo location sought earlier by Sherwood. From the documents and evidence before the Panel, the arrangement would not be binding on government with respect to the Port Hardy site.

Based on evidence provided by B.C.Hydro that they propose to raise their current $0.03 per kilowatt hour rate by 4.5% per year over the next 10 years, and that the rate offered to Sherwood would only be reviewed after 1996 with regard to additional transmission cost, a rate of benefit can be calculated. Notwithstanding the fact that B.C. Hydro sells surplus power to the United States market at the $0.02 rate on an interruptible basis, the Panel accepts B.C. Hydro's testimony that it does not sell interruptible power within the Province. Therefore the rate offered to Sherwood represents a benefit that gives the proponent, based upon one calculation (file 549-PS.234) an advantage of some $16 million between a 1993 start and 1996.

The witness present at the hearings on behalf of B.C. Hydro, Mr. Loewen, offered the opinion that, in all likelihood, the rate would not change in 1996 and, accordingly, the actual subsidy could be worth tens of millions of dollars:

> "Basically, in the first year it's a $3 million benefit. And it increases at approximately - over a ten year period - by four and a half percent a year." (Loewen: Transcript, p. 2513).

The magnitude of this benefit, and the fact that it would grow substantially over time, has become a major issue. In light of the current B.C. Hydro energy conservation policy, it has been surprising to the Panel that discounted hydroelectricity would be used as a costly attraction for an energy-intensive industry.

It should be noted that the proponent is required to pay for the power line and related equipment. These are substantial costs that have the effect of offsetting the value of the described benefit for the first few years.

Throughout the review process, due to the absence financial analyses of Sherwood, it has not been possible to determine how significant the discounted electricity rate is to the proponent. If, based on the proponent's evidence, it is expected that this plant would be very profitable within a few years of commencement of operations, then it would seem reasonable to expect Sherwood to pay the full industrial rate if not from start-up, then at some early year in the future.

Capital Incentives

Western Economic Diversification Canada (WEDC) and the Province of British Columbia have offered a total of $9.75 million in loans. The federal half is interest-free. From the evidence, it would appear that Western Economic Diversification Canada is firmly of the view that the proponent's project warrants the loan they propose.

The evidence of Mr. Heartwell of the WEDC was surprising to the Panel. He testified that they had predicated the interest-free loan based on the assumption of a $1 million per year hydroelectric subsidy and that the project would produce 250 jobs. When asked if it would make any difference that there were now to be only 130 jobs generated, almost half of those considered by the funder, and that the hydroelectric subsidy was substantially higher than $1 million per year (and increasing over time), Mr. Heartwell responded that he didn't think that these changes made any difference. He also opined that, hypothetically, even if there were to be only one person employed, they would probably still give the grant on the basis of industrial diversification.

Dr. Shaffer informs us that:

> " Western Economic Diversification Canada estimated that the benefit to Sherwood (and interest cost to the government) from these loans would total $4.23 million. It projected an employment level of 400... Using the current employment forecast of 130, the capital subsidy per job would be approximately $32,500." (File 352, p.25).

The decision as to where to place interest free (or reduced interest) loans in western Canada, in what amount and upon what terms is the jurisdiction of the Western Development Fund and the Province of British Columbia. However, in assessing the social (including economic) impact upon Port Hardy and the North Island, the Panel cannot ignore the effect of such a grant upon the net value of the jobs produced by the project.

It is not the Panel's objective to question government decisions on allocation of funding. However, in light of testimony before us, it is our responsibility to state that the allocation decision in this instance appears to have been based on a questionable analysis.

Conclusions and Recommendation

The extent of the hydroelectricity benefit for this plant is higher than the Panel expected, however it is recognized that it is the prerogative of the Provincial Cabinet to decide to make such commitments.

The Panel recommends that the provincial government carefully review the entire issue of the power rate offered to Sherwood at Nanaimo as to the extension of this offer to any other location. Consideration should be given to financial analyses (beyond the mandate of the Panel) in regard to the proponent's need for this reduced power rate and the duration of the discount.

4.5 QUALITY OF LIFE

The Panel received and heard a great many statements from the public expressing concern for the risk to the quality of life they presently enjoy in the North Island region. These concerns came from two opposing directions: (1) many people feel that without the economic vitality fostered by such new projects as the one under consideration, the quality of community life in the region would diminish significantly; and (2) many people feel that such a project as this could have a deleterious effect upon the environment, upon livelihoods dependent upon the environment (particularly tourism and fishing), and upon human health.

Evidence was presented that services vital to the community would have to be reduced if the mine closed without some replacement economic activity being established. The Panel heard concerns that health, recreation, and education services would be among those to be reduced.

All residents of the region who made submissions to our Panel were concerned that the plant be environmentally safe. However there was a considerable range of opinion regarding the margin of safety. At one extreme, some expressed the view that they trusted the judgement of this Panel and the government agencies with regard to whether this plant would be environmentally safe. At the other extreme, the opinion was expressed that this plant was too much of a risk under any

circumstances and should not be allowed to proceed no matter what measures of safety could be taken.

This latter opinion seemed almost unanimously held in Sointula and Fort Rupert, where the residents perceived that they could not afford any margin of risk to their livelihoods. Many of the witnesses at the hearings and many of those who thoughtfully wrote to our panel expressed the view that, if their fears of environmental damage could be overcome and if they could be assured that the plant, through the imposition and enforcement of rigorous standards, would not damage the health of humans, fish and wildlife, or the environment itself, then they would not be opposed to the plant going ahead.

It was made clear to the Panel, however, that few residents of the region are prepared to risk the quality of life and environment currently enjoyed. From the Panel's perspective, all residents of the region testifying indicated that they wanted to protect these qualities for themselves and future generations. The variability in sentiments largely revolved around the degree of assurance that this plant would not cause a diminishment of this quality, and the degree to which economic activity was seen as important to sustaining the quality of life in the region.

As earlier determined in this report, in the judgement of this Panel it is feasible to design and operate this plant such that it would meet stringent criteria for environmental protection. Furthermore, it must be recognized that this would be a small scale plant, in comparison to a pulp mill or the Trail smelter for example. Although this type of heavy industry is new to the region, the scale and design of this plant are unlike the images of a major industrial plant that are commonly conjured up. By all comparative standards, this would be a small, relatively low impact operation.

Assessing the social impact of a project such as this is indeed a challenge. We must, of course, take into account the views of people who live in the various centres of the North Island. But the task is not so simple as conducting a referendum and letting that result make the decision. Our mandate is to endeavour to judge as best we can from all of the evidence before us as to what in the long run will be best for the area. We have been charged with the responsibility of exercising our best judgement as to whether the social impact would be favourable or unfavourable and upon that basis, to make a recommendation.

Conclusions and Recommendation

Based upon consideration of all the evidence, including submissions and opinions expressed, the Panel concludes that, it would not significantly diminish the quality of life nor compromise the future of the region, provided that it is designed and operated in accordance with all of the specifications of this report.

On the other hand, the Sherwood plant would add needed economic activity in the Port Hardy area and thereby enhance the economic stability of that community.

Subject to all of the other social and environmental recommendations of this Panel, particularly with regard to siting and permitting conditions, it is our conclusion that the project would have a net positive social impact on the region.

The Panel also concludes, based upon our perspective of this region, that the carrying capacity for this kind of heavy industry is very limited. It is a legitimate public concern that, over time, the combined effect of increasing industrialization would be to substantially alter the present nature of the visual landscape and thereby diminish prospects for the growth of the tourism industry and other economic activities oriented to an undeveloped natural environment.

It is recommended that the final design of the buildings and the stack must have a minimal visual impact on nearby communities or recreational areas.

4.6 NATIVE CONCERNS

From the commencement of this review process, and throughout its duration, the native communities expressed strong interest in the proceedings and in the outcome. The native population and presence in the North Island region is very significant*.

Native Fishery Resources

At the technical hearings and at the community hearings in Fort Rupert and Alert Bay, it was quite evident that the native communities believed that they had nothing to gain from the proposed plant and feared the possible environmental impact of such a smelter on their fishery and their general social and economic well being. It was argued that any effluent from the plant and any dust emissions from the stack would contaminate the marine waters of the area, and would ultimately have adverse impacts on the marine ecosystem, including the salmon and other vital elements of the native food and commercial fishery.

They reflected deep concerns for the healthfulness of their own environment, to be passed on to future generations, as well as concerns about impacts to their socio-economic well-being due to the perceived risk to the fishery. They emphasized that the particular site under consideration is relatively close to an important salmon spawning river and estuary, and that such areas are essential for the productivity of the fishery and very sensitive to contamination. In particular, it was pointed out that salmon spawn and fry may be especially sensitive to pollutants.

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* Native groups participating in this review included:
- the Kwakiutl Band, based at Fort Rupert
- the Kwakiutl District Council, based at Fort Rupert
- the Nimpkish Band Council, based at Alert Bay
- the Musqumagw Tribal Council, based at Alert Bay
- the Gwa-'Sala-Nakwaxda'xw, based near Port Hardy
- the Whe-La-La-U Area Council, based at Alert Bay
- the Quatsino Band, based at Coal Harbour

Lack of Native Benefits

The native people appeared to be unanimous in their condemnation of the proposal, not only because of the possible environmental and consequent socio-economic impact, but also because it would be of no economic benefit to them. They perceived themselves as being asked to bear the risks, with no opportunity for meaningful benefit.

On the matter of employment opportunities, the experience of the native people is that they are seldom hired. This is often because of a lack of suitable educational qualifications, or an unwillingness on the part of employers to implement hiring practices targeted for native people. Also, it is noteworthy that the native people are most keenly involved in economic activities that are closely tied to their traditions, such as fishing. As Dr. Shaffer has advised in his report to the Panel, skills suited to heavy industry employment may not be common among the native population of the region.

The proponent, when asked at the hearings, made it clear that he would not offer native-oriented hiring incentives, but that native applicants would be treated with the same consideration as all applicants for employment. The native community perceived this as a somewhat naive and unrealistic suggestion, as they believe that the level of formal qualifications would automatically exclude most natives of the North Island region.

Significance of Bear Cove Area

The evidence before this Panel suggests that the site proposed for the ferrochromium smelter was once inhabited, seasonally or otherwise, by native people. Evidence to this effect was presented by both Ms. Bussey, archaeologist for the proponent, and Dr. Ham, archaeologist for the Kwakiutl. Three middens have been found on the site, two of which are of greater significance than the third. Two of these sites are located at the head of Bear Cove, and these contained shell fragments, fire-broken rock and stone chips, which tend to indicate some type of inhabitation. The other site is located on the small island, which is adjacent to the proposed plant site and which is the proposed location of the docking/cargo handling facility.

The middens in the cove are evidence, according to Ms. Bussey, that the site had been inhabited, in the range of some 3,000 to 8,000 years ago (Transcript, pp.2406-7). Further field research would be necessary in order to obtain more specific information. The archaeological site on the small

island is significant because, in addition to being a midden, it is possible that the island may have been used for burial purposes. If that island was a burial island, although this has not been established, it would likely have special significance for the native people, who have great reverence for their ancestors.

These archaeological sites are, on the evidence, likely to be of greater significance today in the Hardy Bay area than in recent years, because of the disturbance and destruction of other important archaeological sites in the area. In particular, it was revealed that the B.C. Ferry Corporation terminal, adjacent to the Bear Cove site, and the new log sorting area near the head of Hardy Bay are located over major archaeological sites (EeSu 8 and 5 respectively). Evidence was given that because these sites had been destroyed, it was extremely important to retain the remaining ones.

Beyond archaeological evidence of habitation, there was also oral evidence that the grandfather of one of the witnesses, Mr. Tom Hunt, had been born on the proposed site and that there had once been a smokehouse or longhouse there. No archaeological or more recent physical evidence was submitted to verify this information. Ms. Bussey reported that she had found evidence of chip stones at EeSu 9, which is further indication of substantive occupation. Ms. Bussey opined further that there may have been culturally modified trees that have since been cut down, though she was not able to substantiate that suggestion. Dr. Ham pointed out that he had made only a brief visit to the site and that, in his opinion, Ms. Bussey had not done a complete examination of the site either.

The government's Outdoor Recreation and Archaeology Branch, of the Ministry of Municipal Affairs, Recreation and Culture, filed documents which outline the procedures to be used for such examinations and by developers in protecting archaeological sites. It appears that appropriate investigative procedures were followed, according the provincial agency responsible. Moreover, the proponent has stated and provided documents that show that the identified archaeological sites would not be disturbed by the proposed development. This is consistent with provincial legislation (Heritage Conservation Act) and associated guidelines. Notwithstanding compliance with provincial standards in this regard, the native people of the region feel very strongly that the entire site is of archaeological and cultural significance to them.

The "Douglas Treaty"

On February 8, 1851 the "Quakeolth" tribe of Fort Rupert entered into a treaty with the Hudson Bay Company. This is known as the "Fort Rupert Treaty" or the "Quakeolth Treaty" and was later ratified as binding on Her Majesty (the government). The brief text of this treaty, one of a series of such treaties subsequently referred to generically as the "Douglas Treaties", is contained in Appendix N and is filed as file 507-Govt.53.

In substance, this treaty gave the Hudson Bay Company rights to the lands of the defined area, but permitted the native people the right to occupy their own settlements and fields, the right to hunt over all unoccupied lands and the right to carry on their fisheries and other food gathering activities.

It is the contention of the native people that the "Douglas Treaty" is binding, that they have the right to hunt on this land (presumably this includes trapping), that the proposed plant would, in their view, interfere with their fishery, and that the site is a former settlement and therefore was not included in the lands relinquished under the treaty.

In support of their contention regarding the "Douglas Treaty", the native people rely upon two cases. In the Saanichton Marina case [Saanichton Marina Ltd. v. Claxton (1987) 36 B.C.L.R. (2nd) 79 (C.A.)], a decision of the B.C. Court of Appeal, it was established that native people subject to these treaties not only have a right to fish, but also the right to preserve the places where that right can be exercised. There the proposed marine development was not allowed to proceed. In addition, they rely upon the Hunt vs. Halcan Logging case [Hunt v. Halcan Log Services Ltd. (1986) 15 B.C.L.R. (2nd) 165 (S.C.)]. This dispute involved Deer Island, which is situated near Fort Rupert. The decision of Mr.Justice Trainor (B.C. Supreme Court) was to grant an injunction on behalf of the Kwakiutl Band to halt further logging of that island, in consideration of both their land claim and their rights under the "Douglas Treaty".

The Land Claim

In June 1984, the Kwakiutl First Nations Land Claims Council filed with the Government of Canada, Department of Indian Affairs and Northern Development, a claim based upon aboriginal title to all of the lands along the east coast of the northern part of Vancouver Island, from Comox to a point beyond Port Hardy at the north end of Vancouver Island. This claim, as filed, includes the proposed site for this plant. This claim was accepted for negotiation by the Minister of Indian Affairs and Northern Development in February 1988 (file 256-Govt.24, p.4).

One of the provisions of the acceptance by the Ministry of that land claim was that it did not apply to Douglas Treaty lands. In other words, it is the position of government in accepting the land claim for negotiation that the Douglas Treaty lands would be excluded.

It is the position of the Native people that they support the "Douglas Treaty" as such, and that the project site was a village site under that treaty and that the area would be subject to their hunting and fishing rights. In any event, they do not agree that those lands would in any way be excluded from negotiations with the government under the land claim as filed.

Another term of the acceptance by the federal government of this and other comprehensive native land claims is that the Province of British Columbia become involved in the process. In that regard, in the summer of 1990, the Premier of British Columbia stated publicly that the Province would become involved and would participate in negotiating comprehensive land claim issues. [According to statements made by the Premier, participation did not mean that the Province would assume any financial responsibility.]

In reference to their land claim rights at law, the Kwakiutl Band also relies upon the 1985 Meares Island case [MacMillan Bloedel Ltd. v. Mullin; Martin v. B.C. (1985) 61 B.C.L.R. 145 (C.A.)]. In that case (a decision of the B.C. Court of Appeal) an injunction was upheld in favour of the native people with regard to preventing logging until the land claim of the Nuu-chal-nuth could be resolved. It was there determined that the native people had presented sufficient evidence of earlier use and occupation of the island (such as fish traps, canoe skids and culturally modified trees) to warrant the granting of an injunction pending a full trial of the issue.

The Kwakiutl Band maintains that they too have produced proof of earlier historical occupation and that they would be entitled to an injunction to restrain logging or the building of any plant

pending the conclusion of the land claim, either by negotiation or by litigation. They argue, therefore, that we should not recommend that the plant be permitted to proceed until their land claim, including their "Douglas Treaty" rights, have been finally settled through negotiation or in the courts.

Negotiations with the Proponent

The native evidence, as it was adduced at both Port Hardy and Fort Rupert, with the support of the native people at Alert Bay, was fundamentally to the effect that they could and would not permit the plant to be built. They made it clear that they would take whatever measures necessary to stop the construction of the plant.

The proponent's response to this was that they would not wish to proceed with the construction of the plant unless they had "made a deal" with the native people. The proponent advised that they were prepared to negotiate with the native people in order to obtain an agreement to proceed with the plant. Furthermore, it was stated that without such an agreement, the proponent did not intend to proceed. The native response at the hearings to that suggestion was that they would never agree to the construction of the ferrochromium plant on that particular site.

Assessment of Native Issues

From a strictly jurisdictional perspective, it is likely that this Panel could ignore the "Douglas Treaty" and land claim aspects of the evidence. Our mandate does not expressly include consideration of these native issues.

In that regard, it is quite clear that this Panel lacks the jurisdiction to make a finding in reference to the validity or scope of the land claim and its application to the proposed site or the specific application of the "Douglas Treaty". Without doubt, those are matters for a court to decide, and not our panel.

However, taking a more pragmatic view of our mandate, we cannot ignore the body of evidence and the pleas of the native people surrounding these issues, in consideration of the social impact component of the Panel's mandate. The native people constitute a significant segment of the North

Island region. They have villages in close proximity to the proposed site. They have stated categorically that they will not permit the plant to be built. It is notable that the proponent has also stated that it would not seek to construct its plant on that site without an appropriate agreement with the native people.

Although the two levels of government offered capital incentives to the proponent and the Ministry of Crown Lands and the District of Port Hardy offered the site for the project, it does not appear that anyone considered the position of the Kwakiutl with regard to its "Douglas Treaty" rights or its comprehensive land claim. From the evidence before this Panel, it would appear that, prior to this review process, the proponent had been unaware of these native issues. Although this is somewhat surprising to the Panel, there is no evidence to indicate what the proponent's knowledge was at the initiation of this proposal with regard to these important native issues.

With these social realities in mind, should the Panel recommend the Bear Cove location as the appropriate site? Would it be fair to the native people to do so before they have had an opportunity to have their claims resolved? Would they not, as in the Meares Island case (cited above), be entitled to an injunction? These are legitimate considerations for the Panel and for government.

It is the view of the Panel that, until the native people of this area have had sufficient opportunity to settle or litigate with the two levels of government the land claim and the "Douglas Treaty" rights, or until the proponent has concluded an agreement with the native people with respect to the site in question, the project proposed should not be permitted to proceed on that site.

On the other hand, it may be prudent for government to offer alternative sites near Port Hardy, not on Hardy Bay, which might suit the interests of both the proponent and the native people. Such action could, in our opinion, avoid a major rift between the native and non-native communities in the region. That rift, incidentally, could far outweigh any positive social or economic value from the proposed plant.

Recommendation

Notwithstanding the project's other merits, including its manageable environmental impact and its net social benefits, this Panel recommends that this project not be authorized on the selected site until such time as an agreement can be reached between the proponent and the native people, or until the outstanding land claim and treaty issues have been resolved by litigation or settlement.

5.0 PROJECT MONITORING

Introductory Comments

Adequate project monitoring is necessitated by both social and environmental considerations. This chapter reviews the basis for such a program, in terms of the evidence and foregoing conclusions and recommendations of the Panel, and recommends the fundamentals of a monitoring program.

Sherwood presented the outline of a monitoring program in the EIS Addendum, Section 6, and at the hearings. The latter is summarized by file 449-Pro.78, "Monitoring Program Objectives". A supplement showing sites for sampling was included. The program, as presented, was comprehensive, possibly excessively so.

The proponent's monitoring program specified protocols (frequency, parameters) for sampling and testing to collect data on:

(1) stack emissions, fugitive emissions, seawater cooling and storm water overflow;

(2) terrestrial environments: soils, vegetation and wildlife;

(3) freshwater: chemistry and periphyton;

(4) marine ecosystem: twelve different categories including water, sediment and biota;

(5) meteorological conditions and air quality, including dust canisters, gas monitoring and moss bags.

The proposed frequency of monitoring the receiving environment varied from once to six times annually for the marine program, annually (periphyton) and quarterly (water chemistry) for freshwater ecosystems, and annually for terrestrial.

Point source monitoring was varied. For example, in the air monitoring, dust fall canisters were specified monthly, and there was to be quarterly sampling of SO_2 and NOx levels in ambient gas.

The monitoring program of the EIS Addendum was reviewed extensively at the hearings and in documents filed by consultants retained by the Panel. Refer especially to files 393-Pan/Ex.31 (Lemmon), 473-Pan/Ex.40 (Chapman), 347-Pan/Ex.20 (Caton). Additionally, extensive discussion of the permitting, monitoring and compliance conditions took place at the final hearing December 1, 1990. This latter discussion, based on the material in file 560-PS.240, provided a perspective to the Panel on the proponent's views of the monitoring and compliance process, in reply to suggestions made in the document submitted by counsel to the Concerned Residents of the North Island.

Earlier, Dr. Thomas, consultant for the intervenors, observed that:

> "Hypotheses should be outlined and specific details for testing those hypotheses should be given. Rationales should be provided for choosing indicator species and for choosing specific locations (and) frequencies of sampling." (file 296-Pan/Ex.16).

While this comment was available to the proponent in the earlier months of the review process, it parallels the main critique of the various experts who examined the monitoring program as presented in the later months of the review.

It is clear that to maximize the confidence of the public, in terms of the compliance of the facility with its permit levels and conditions, a monitoring program with the following characteristics is required.

It is recommended that a comprehensive monitoring program be required, including baseline studies, start-up monitoring including stack testing, sampling locations and protocols, monitoring guidelines, and plant shutdown specifications, as outlined in this report (Section 5).

Initial Baseline Studies

(1) **Sufficient baseline data, particularly on the existing marine ecosystem, is necessary in order that any changes induced by the facility can be detected following start-up.**

Consultants to the Panel have recommended a minimum one year study. Monitoring techniques such as moss bags for air and analysis of trace metals in macrophytes (i.e. eel

grass), crab (leg tissue), and so forth, require prior establishment of baseline levels in these biota. Preferably these would be on a one year cycle, in order that "indicators of problems developing in the resource can be sensed before the problems become critical" (Chapman: file 473-Pan/Ex.40).

It is important that the ecosystems be defined in terms of biomass and speciation such that changes can be detected. The need for data collection over a one year cycle was identified in several instances. For example, migratory birds and migratory fish species tend to follow annual cycles.

Furthermore, foreshore data collection must proceed well before commencement of construction. Trace element levels in foreshore biota can be critically affected by silting or run-off from construction activities. This work needs to be designed so as to avoid being rendered invalid by the on-site changes during the construction period.

(2) **Meteorological data must be improved, especially in terms of extent of data gathered in communities in proximity to the plant.**

Consideration should be given to further data collection as needed to complete the air modelling requirements specified earlier in this report.

(3) **Physical oceanographic baseline data on Hardy Bay must be improved. In particular data from stations A and B was judged to be inadequate by the Department of Fisheries and Oceans and Environment Canada. This should be a one year program (Lewis: file 361-Pan/Ex.26).**

This oceanographic work is of particular value in assessing possible effects on the nearby fish farm or other food harvesting operations. Current information is needed with regard to the distribution of suspended sediments or other contaminants, and for confirming the projections on the dispersion and impact of the heated seawater. Should the final plant design employ the coolant effluent pipe for storm water and treated process water, these studies will be even more critical.

Start-up Monitoring

It is noted that air monitoring and other protocols refer to the steady state or the operational status of the particular facility. For example, dust fall canisters are monitored monthly and SO_2 and NOx levels in ambient air are monitored quarterly.

As the Sherwood facility will gradually increase its production over its first year or more, until full production levels are reached, it is important that the permitting and monitoring processes make allowances for this phasing-in. A phased-in monitoring program, timed around trial runs, would achieve this goal. Such an approach, particularly with regard to providing an early indication of SOx, NOx and dust fall (including total chromium content), would increase confidence in the overall ability of the facility to meet projected operational levels. A stack test should be carried out at regular intervals during this period.

During the start-up period, the best locations should be determined for the longer term monitoring program.

The proponent's proposals for meteorological sampling quarterly or at the two worst dispersion periods of the year, are not consistent with the six-day cycling approach of the B.C. Ministry of Environment and Environment Canada. These are referred to by Sagert in file 261-Pro.21. Careful assessment of sampling schedules to capture "worst case" air scenarios should occur during the start-up program. In other words, the air sampling technique should be specifically designed by hypothesis to (a) confirm modelling projections for annual maximum values, and (b) provide assurance to residents of nearby communities that the projection of minimal risk is being achieved.

Sampling Locations and Protocols

The need for a testable hypothesis in choosing monitoring sites and in determining the frequency and nature of the samples is particularly critical. A written rationale for the interpretation of each result, in terms of overall ecosystem impact, is also strongly advised. Useful end points and components should be selected. (Chapman: file 473-Pan/Ex.40).

The current sites suggested by the proponent (file 449-Pro.78) do not meet the criteria for monitoring. They are poorly defined geographically and appear scattered arbitrarily. For example, marine sampling sites in the inner parts of Hardy Bay will be subject to multiple source contamination from various harbour activities and pollution sources.

Sites and sampling need to be chosen in collaboration with the Department of Fisheries and Oceans, Environment Canada, and the B.C. Ministry of Environment. This selection can be made following an analysis to determine:

(1) Relevance and usefulness (information potential) in regard to the facility's impacts on the environment. For example, Dr. Chapman advises that "...plankton has high natural variability; do not measure plankton community structure". However, the proponent should include specifically checking for the presence of plankton species toxic to fish.

(2) Relevance to critical environmental habitat and populations for other values. For example, this would include commercial fisheries of all types, local salmon spawning habitat, and so forth. The inadequacy of the proponent's current monitoring proposal in this regard is pointed out by Dr. Lewis in reference to the oceanographic data:

> "Note the sampling program and the station sites are not provided in the (EIS) Addendum. This must be done. The lack of information in Section 6.2.4 (Page 6.8) gives the company the right to sample whatever and wherever they wish." (file 361, p.4)

Recommendations for Monitoring the Plant

In conjunction with the B.C. Ministry of Environment, and as a condition of the permitting process to facilitate monitoring and enforcement, the Panel recommends that:

(1) **Emission and effluent limits must be set, rather than using objectives or guidelines.**

(2) **Prescriptions for action (i.e. shutdown), or penalties, or emergency procedures (such as storage of effluent) must be set in conjunction with the emission and effluent limits.**

(3) There must be specification of actions to be taken when pre-set levels of impact on the receiving environment are reached. These should be specified either in concentrations of contaminants (ambient air and water quality), or effects on ecosystems. The latter may be "no effects" levels, particularly for the productive Quatse River estuary. These would be specified for air, soil, sediment and biota.

(4) Procedures and contingency plans must be submitted for maintenance, emergency and major failure situations that would require shut down or other such action. Such situations include:

- Failure in a baghouse.
- Fan failure.
- CO boiler combustion failure.
- Unauthorized use of flare stack.
- Steam ejector failure.
- Discharge of noncompliance effluent.
- Foaming, pouring, charging and casting incidents (metal or slag).

(5) In view of the novel technology and developmental aspects of this plant, reporting mechanisms for routine informing the Ministry of Environment of such incidents (as identified above) should be established for a five year period.

(6) Government authorities must institute surveillance of the project and appropriate enforcement procedures. These should include:

(a) Regular collection of test results, including a special one year study of chromium levels from air emissions, effluent, and leaching of slag and raw materials.

(b) Unannounced sample collection by the Ministry of Environment, with independent analysis (including air, effluent and environmental samples -- biota, sediment).

(c) A quality assurance/quality control review by the Ministry of Environment, including assessment of low level (trace) chromium test procedures. An outline of

relatively conventional requirements is given in file 449-Pro.78. It is particularly important for the Ministry to make an assessment of the following:

i) detection levels in the proponent's procedures (especially chromium);

ii) quality assurance/quality control on leaching tests of slag and raw materials, particularly with respect to precision and accuracy;

iii) sampling protocols for biota and sediment, particularly in relationship to hypothesis targets for surface sediment layers and habitat locations.

(7) There must be an investigation of CrVI/CrIII operational levels and bioavailability (solubility of chromium particulate in acid and base) after operational levels are reached and during the start-up phase.

(8) Finally, it is recommended that a focused, rationalized monitoring program must be designed that makes hypotheses on environmental impacts, designs a specific sampling sites and protocols to test them, and then provides action levels and remedial actions to be undertaken.

Recommendations for Monitoring for Public Health

Two issues are involved: (a) exposure of the public to contaminants, and (b) worker health and safety.

It is recommended that public exposure to contaminants should be monitored by the following methods:

(1) Air monitoring in Beaver Harbour and Port Hardy, including total chromium analysis: Consideration should be given to frequent 24-hour high volume sampling in these locations. Dustfall samples should be subjected to CrVI/CrIII ratio analysis during the phase-in of the plant.

(2) **Regular analysis of the public water supply for municipalities affected, including source and after-treatment sampling.**

(3) **Determining the coliform count in the vicinity of the seawater cooling outfall regularly, and transmitting the data to the public health office in Port Hardy. In this context, Sherwood must provide dispersion information for the outfall when the heat exchanger system is not functioning.** It is observed that if the municipal sewer outfall into Hardy Bay could be brought into compliance, this would be a logical and accessible means of both increasing the margin of public safety and mitigating the impact on Hardy Bay from the combined effects of the two outfalls.

(4) **Monitoring the noise impact from the plant on surrounding residential communities, using measurements before and after commissioning. The proponent has undertaken to make such measurements. The public health office should assess effects.**

(5) **Monitoring for odour: The potential for odour is almost entirely in regard to "TRS" (total reduced sulphur), or H_2S in this case. Exclusion of this nuisance should be confirmed, based on start-up tests on slag quenching (cooling); these would be run by the proponent.**

(6) **Determining residual risk to human populations of Chromium VI, as a known carcinogen: This analysis would optimally be based on modelling projections, with the data obtained as outlined above.**

Worker health and safety has been addressed by the Ministry of Health (file 358-Govt.36). Their recommendations, as follows, are supported by the Panel:

> "It will be important that the environmental monitoring program be in place and working under the supervision of trained staff prior to production start-up. This will enable baseline data to be accumulated as well as close monitoring during the transition to full production, in the event of start-up problems.
>
> "The particulate sampling technology chosen should be able to measure the respirable particulate fraction, which is defined by the USEPA to include particulates less than or equal to 10 micrometers. Large particulates and gases (for chromium VI) should also be measured to monitor the overall impact on the ambient air quality." (Emerson: file 358).

This draws attention to the respirable particulate problem.

It is recommended that Sherwood implement a workplace hazards program, in cooperation with the Workers Compensation Board, that addresses issues such as the safe storage of hazardous materials (solvents, gasoline, chemicals), and spill clean-up protocols to protect workers and to prevent excursions of contaminants and pollutants into the environment.

The Panel notes that the current "TLV" level of 0.05 mg/Nm^3 total chromium is at variance with the "NOAEL" value for chromium ambient air concentrations, as discussed in Section 3.2 of this report.

Based on these considerations are the following recommendations:

(1) **The Panel recommends that the Workers Compensation Board re-assess the use of this value, with a view to adopting the more conservative workplace ambient level of 0.05 ug/Nm^3.**

(2) **Furthermore, it is recommended that worker health and safety education, and the acquisition of baseline health information about the workers, should be undertaken as priorities during start-up.**

(3) **Finally, it is recommended that appropriate monitoring of chromium levels in employees before and after start-up should be undertaken.**

Plant Shutdown

All too often, the environmental impacts of dormant or abandoned industrial sites remain as time capsules, eventually requiring a future generation to address clean-up.

Long term shut-down, or plant abandonment, is a more serious matter. The proponent has stated that if the plant is abandoned, then a clean and useful industrial site will be available. In the view of the Panel, this is an unrealistic perspective.

As a new standard of major industrial project planning, the Panel recommends that contingency plans be established from the initiation of the Sherwood project to cover both short term and long term shut-down of operations.

It is recommended that for short term shut-down, the following measures should be required:

(a) the continued monitoring and treatment of storm water, including run-off from stockpiled raw materials, slag and waste;

(b) site clean-up of all exposed material before or at the time of a shut-down;

(c) continued analysis of storm water during the shut-down period, unless there is sufficient storage capacity to retain all run-off (for example, during a two week holiday period);

(d) in the absence of a full site clean-up, continued operation of the full analytical and water treatment facility on a standby basis, if storage capacity for the shut-down period is not available;

(e) provisions written into waste permit conditions ensuring that the financial resources will exist to carry out the monitoring and clean-up work necessitated by shutdown; this may necessitate the posting of a suitable financial bond.

It is recommended that, in the event of long term shut-down, all wastes, raw materials, chromium-bearing slag (and other toxic elements) should be appropriately disposed of, and there should be final water table and soil testing to complete the shut-down work.

The Panel considers that it is essential that the permitting process achieve not just an indication from the proponent of commitment to these measures, but rather that written and financial guarantees for de-commissioning procedures be provided.

* * * *

APPENDIX A

TERMS OF REFERENCE

Province of British Columbia

NEWS RELEASE

B.C. MINISTRY OF ENVIRONMENT
FEDERAL ENVIRONMENTAL ASSESSMENT
REVIEW OFFICE

January 12, 1990

1990:5

MINISTERS NAME PANEL TO REVIEW SHERWOOD PACIFIC FERROCHROMIUM PLANT

In response to the concerns of Vancouver Island residents, the federal and provincial governments have appointed a panel to conduct an independent review of the environmental and social effects of the Sherwood Pacific ferrochromium smelter proposed for the Port Hardy area.

Federal Environment Minister Lucien Bouchard and provincial Environment Minister John Reynolds today announced the names of the panel members and released the Terms of Reference.

Bryan Williams has been named Chairman. The other two panel members are Dr. Paul West and George Davies.

The review is being managed under the B.C. Environment Management Act but is also being established in accordance with the requirements of the federal Environmental Assessment and Review Process (EARP).

If, at the completion of its review, the panel concludes that the proposal is acceptable, it will explain the basis for that conclusion and recommend terms and conditions under which the smelter could proceed. If the panel concludes that the proposal is unacceptable, it will similarly explain the basis for its conclusion.

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Bouchard stated "my colleague, the Honourable Charles Mayer, Minister of Western Economic Diversification, recognizing the need for residents of Vancouver Island to contribute to decisions on this project, has asked me to work with the Province in convening the panel. It will concentrate on the environmental and social impacts of Sherwood's vacuum metallurgical process."

Reynolds said: "Mr. Williams and his fellow panel members are well qualified to carry out their mandate to conduct a credible, unbiased review.

"The panel will provide ample opportunities for public review of the facts and for comment on the proposal, including public hearings in the Port Hardy area."

An initial assessment of the project at its then proposed Nanaimo site was carried out last year in accordance with federal EARP guidelines. When that review gave the project conditional approval, Sherwood Pacific was offered a repayable contribution of $4.875 million from Western Economic Diversification Canada and a matching loan from the provincial government under the joint Canada-B.C. Industrial Development Agreement.

Since then, concern on the Island about the project led to the decision to ask for a formal public review.

Neither the Government of Canada nor the Government of B.C. will release any funds to Sherwood unless and until all environmental requirements have been identified and met.

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Permits for the smelter operation will be required under the B.C. Waste Management Act, which regulates air and water discharges. Reynolds made it clear that no decision on permit applications will be made until the panel completes its work.

"The panel's recommendations will be used by my Ministry to evaluate permit applications," Reynolds explained. "This will eliminate the need for separate public consultation on the permits."

The Sherwood Pacific project is a joint venture of the Wooding Corporation of New Jersey and the Elders Finance Group of Australia. The proposed plant would cost about $45 million to construct, employ about 200 people and produce 25,000 tonnes of ferrochromium alloy per year. Ferrochromium is used in the manufacture of stainless steel.

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PORT HARDY FERROCHROMIUM PLANT REVIEW PANEL
MEMBERS BIOGRAPHIES

Mr. Bryan Williams, Q.C. - Chairman

Mr. Williams is a senior partner with the Vancouver law firm Swinton and Company. He is a practising lawyer and former president of the Canadian Bar Association. He is actively interested in environmental issues and is currently a Director of the World Wildlife Fund of Canada. In 1986, Mr. Williams chaired the Special Provincial Government Commission on B.C. Wilderness Land Allocation.

Mr. George Davies

Mr. Davies is a professional engineer with extensive knowledge and experience in the metallurgy field. He is currently working as a private consultant and lives in the Vancouver area.

Dr. Paul West

Dr. West is the Director of the Environmental Studies Program at the University of Victoria and is an Associate Professor with the Department of Chemistry. He joined the University of Victoria in 1969 shortly after completing his Ph.D. in chemistry.

PORT HARDY FERROCHROMIUM PLANT REVIEW PANEL
TERMS OF REFERENCE
JANUARY 1990

Background

Sherwood Metallurgical British Columbia Corporation is proposing to develop a ferrochromium production facility near Port Hardy, British Columbia. The plant is to have an initial production capacity of 25,000 tonnes of ferrochromium alloy per annum.

The project, previously proposed at Bamberton and Nanaimo, has been undergoing government economic and environmental assessment since October 1988. As part of this assessment, a preliminary environmental evaluation of the Bamberton proposal was prepared by Rescan Environmental Consultants Ltd. in November 1988.

An Initial Environmental Evaluation report on the Nanaimo site, was submitted in early 1989 on behalf of the project proponent by Norecol Environmental Consultants Ltd. in accordance with the requirements of the federal Environmental Assessment and Review Process. This report was prepared with input from federal and provincial environmental agencies.

As a result of growing public concern, Nanaimo City Council passed a resolution on October 16, 1989 calling for a full public review of the proposal. In recognition of the broad public concerns that led to the passage of this resolution and the fact that public concerns have also been expressed regarding the Port Hardy location, the federal and B.C. governments have established a joint Review Panel to conduct a public review of the ferrochromium production proposal. The Panel has been established under the authority of the B.C. Environment Management Act and meets the requirements of the federal Environmental Assessment and Review Process.

These Terms of Reference for the Review Panel have been approved by both the federal and British Columbia Environment Ministers.

Panel Membership

The Panel is to be comprised of a chairman and two members. All three will be joint appointments made by the federal and British Columbia Environment Ministers.

Panel Mandate

The mandate of the Panel is to conduct a public review of the environmental and social effects of the proposed ferrochromium plant at Port Hardy. The Panel shall identify the impacts associated with the proposal, assess their significance and investigate options for their reduction or elimination. Specifically, the Panel shall address the potential social impacts including those relating to employment, regional development, and recreation.

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Panel Mandate (Cont'd)

Environmental impacts to be reviewed should focus on construction impacts on the local ecosystem, the potential impacts of raw material storage and handling, the process technology, and all wastes or by-products associated with the process. Thorough consideration shall be given to the proposed waste treatment and handling methods, including the use of salt water or water to air discharge for process cooling. Specific attention is to be paid to the toxicity of all materials that will be exposed to, or discharged to, the environment.

In fulfilling its mandate, the Panel shall provide full opportunities for public review and comment including public hearings to be held in the Port Hardy area.

Upon completion of its review, the Panel shall provide a written report and recommendations to the federal and British Columbia Environment Ministers on the environmental acceptability of the proposal. Recommendations shall be provided on the environmental and social acceptability of the proposed ferrochromium production technology and the specific application of this technology at the Port Hardy site. If the Panel concludes that the proposal is acceptable, it shall explain the basis for that conclusion and recommend terms and conditions under which the ferrochromium facility could proceed. If the Panel concludes that the proposal is unacceptable, it shall similarly explain the basis for its conclusions.

No B.C. Waste Management permits will be issued until the Panel has submitted its recommendations. The review process will include opportunities for public comment on the terms and conditions that could be applied to these permits and will preclude the need for separate public information meetings to review permit applications. The Panel's recommendations will be considered by the Province in adjudicating permit applications.

Construction activities on the proposed site shall not commence until after the Panel has completed its review and then only if the government decision is to allow the proposal to proceed.

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Panel Review Steps
The main steps in the Panel review process shall be as follows:

1. The Panel will examine all existing documentation on the ferrochromium plant proposal and its environmental and social impacts.

2. The Panel will undertake an issues scoping exercise to determine those issues that should be the focus for the review and will assess the need for additional information to adequately address these issues as well as information required to assess impacts associated with the Port Hardy site. An opportunity for public input shall be provided at this stage.

3. The Panel may request additional information from the proponent to respond to identified information deficiencies. Once the Panel is satisfied that it has adequate information to form the basis for fair and complete public hearings, it will announce its plans and schedule for the public hearings.

4. In advance of the public hearings, written submissions will be solicited from the public and other interested parties.

5. Public hearings will be held by the Panel in the Port Hardy area. The hearings will be non-judicial but will be governed by clear rules of procedure.

6. Following the hearings, the Panel will prepare its report and recommendations and submit them to the federal Ministers of Environment and Western Economic Diversification and the B.C. Minister of Environment.

7. Following review of the Panel report by the Ministers, it will be made public.

Procedures
Detailed written procedures for the conduct of the review, including the public hearings, shall be established by the Panel and made available to the public.

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Technical Specialists
As deemed necessary and appropriate by the Panel, technical specialists may be engaged to assist with the examination and understanding of specific issues. At the discretion of the Panel, these individuals may be made available to other review participants to assist with their understanding of these issues. The Panel's procedures shall contain further detail on the role and availability of these specialists.

Secretariat
Officials of the B.C. Ministry of Environment and the Federal Environmental Assessment Review Office, or persons contracted by those agencies, shall serve on the Secretariat to the Panel.

APPENDIX B

OPERATIONAL PROCEDURES

OF THE

PORT HARDY FERROCHROMIUM REVIEW PANEL

Part I: General Procedures

Part II: Hearings Procedures

PART I: GENERAL PROCEDURES OF THE PORT HARDY FERROCHROMIUM REVIEW PANEL

It is the firm intention of this duly appointed review panel to conduct a fully public, fair, thorough and accessible process, including the comprehensive scoping of issues and a public hearings process.

The following procedures are based upon those identified by the Federal Environmental Assessment Review Office (FEARO) as appropriate to review panels undertaking a Federal Environmental Assessment and Review Process (EARP). Each such panel adopts a similar set of procedures designed to satisfy the requirements of EARP for a fair and thorough public process; specific variations in these procedures may be chosen by each such panel in consideration of the particular circumstances of the subject and terms of reference for the review.

The mandate of the Panel is to conduct a public review of the environmental and socio-economic effects of the proposed ferrochromium plant at Port Hardy. The Panel has been instructed to identify the complete range of impacts associated with the proposal, assess their significance and investigate options for their reduction or elimination. Upon completion of its review, the Panel will provide a complete report of its findings to the federal and provincial governments; this will include recommendations for government action in the matter.

In fulfilling its mandate, the Panel is required to provide full opportunities for review and comment by the public. This includes public access to all information submitted to and considered by the Panel, as well as public issue-scoping meetings and public hearings to be held in communities in proximity to the proposed plant.

The purpose of this statement of operational procedures is to provide the public with a clear understanding of the process, the opportunities for input, and the principles of conduct that govern the Panel and the process. These procedures may be amended by the Panel as deemed appropriate and such amendments will be made public.

General Principles

a) All contacts with the Panel must be through the Executive Secretary to the Panel. The Panel and Panel members will avoid private oral or written communications with the public, special interest groups, the proponent and consultants to the proponent, and government agencies. The Panel will only engage in meetings or discussions of a public nature.

b) All information submitted to the Panel for its consideration with respect to the proposed ferrochromium project will be treated as public information, and will be made accessible to the public. This includes public submissions (letters and briefs), technical reports, analyses of technical reports, and all other materials. The Panel is not obliged to reprint documents that have already been published (publicly printed) by other bodies, unless copies cannot be readily obtained or viewed by the public.

c) Public access to information will be provided for by the supply, for reference purposes, of a copy of all documents and submissions to each of the following public offices:

- Offices of the North Island College in Port Hardy, Port McNeill, Sointula, and Alert Bay.
- Office of the Kwakuitl District Council.
- Port Hardy branch of the Vancouver Island Regional Library, on a 24 hr.loan basis.
- Nanaimo branch of the Vancouver Island Regional Library.
- Victoria Public Library, downtown branch.
- Office of the West Coast Environmental Law Association in Vancouver.

d) The Panel's final report will be submitted to the federal and provincial Ministers of Environment. This report will then be made public by government as a requirement of the EARP Order-in-Council.

e) The Operational Procedures are designed to be both efficient and fair to all review participants. The Panel review will provide opportunities for the participation of government agencies, native organizations, communities, public groups, professional associations, and individuals interested in or concerned with the proposed industrial facility. Emphasis will be given to those who have interests in the vicinity of Port Hardy, as well as other communities that may be considered near to any potential environmental impacts, especially as might be carried by wind or water. Submissions from other persons or interest groups more distant from the proposed location are also welcome.

f) The Panel's public hearings will be conducted in a non-judicial but structured manner to allow for fair and full examination of all information presented to the Panel.

g) Internal discussions of the Panel are confidential to the Panel and the Executive Secretary to the Panel. This will include discussions with consultants hired by the Panel, although any findings or reports produced by these consultants will be made available to the public.

Review Steps

The Panel expects that its review will include the following main steps:

a) Existing documentation and the proponent's proposal at Port Hardy will be collected and reviewed by the Panel to confirm what studies have been done, what information is available to the Panel, and what further information is required.

b) The public and interested organizations are invited to make written submissions (letters or briefs) to the Panel at any time in the process, from appointment of the Panel to the closure of the final public hearings. These submissions should contain the name and address of the sender. Submissions may identify issues of concern, questions to be addressed in the review, information for the Panel's consideration, or proposed solutions or recommendations for action with respect to the subject of the review.

c) An issues scoping process designed to identify and priorize the key issues to be addressed during the review will be conducted. Public and government agency input to this process will be accommodated through community meetings and request for written submissions. The community meetings will be held in various communities in proximity to the proposed industrial facility, including Port Hardy, Fort Rupert, Port McNeill, Alert Bay, and Sointula.

d) Based upon written submissions and issue scoping meetings, the Panel will compile a list of issues and concerns that must be addressed by the proponent providing sufficient information. This list will be provided to the public, to government agencies and to the proponent. Based upon and attached to this list will be terms of reference for the proponent's preparation of a complete Environmental Impact Statement (EIS) and specifications of other information deemed significant to the review. Government agencies will be requested to supply information to the Panel and the Panel may, if deemed

appropriate, commission independent consultant studies.

e) Prior to any public hearings, a minimum of 35 days will be allowed for the public review of the proponent's completed EIS and any other significant information required from the proponent by the Panel. During this period, written comments on the adequacy and completeness of this information may be made to the Panel.

f) Based upon written comments received and upon its own review and evaluation, the Panel will decide on the acceptability or adequacy of the information for use in the public hearings stage of the review. If the Panel deems that the information is not adequate, the Panel may ask for further information before holding the public hearings.

g) Any supplementary information from the proponent (or consultants to the proponent) will be circulated to the public in advance of the hearings and will be available at the hearing locations for public scrutiny.

h) Public hearings will be held by the Panel in communities in proximity to the proposed industrial facility. A schedule of hearings and locations for hearings, together with procedures for the hearings, will be published at least 30 days in advance of the start of the hearings.

   The purpose of these hearings will be to allow for a full public review and examination of all information received by the Panel as well as to solicit public comment on matters relevant to the Panel's mandate. In advance of these hearings, written submissions may be made to the Panel at any time on matters of issue scoping or substantive content. All such submissions must be transmitted to the office of the Executive Secretary of the Panel, from where they will be made available to the Panel and to the public.

i) The Panel's report containing its findings, conclusions and recommendations will be completed following the public hearings and the Panel's deliberations. This report will be submitted to the federal and British Columbia Ministers of Environment.

Technical Specialists

The Panel may secure the services of independent specialists to provide information and analysis on complex technical, scientific or socio-economic subjects or issues that may be raised throughout the Panel review process. These persons or firms will serve the review by providing information and analysis on specific technical issues, as assigned by the Panel, in addition to raising issues and questions which may otherwise be overlooked. The appointment of these specialists will be publicly announced. All such specialists retained by the Panel will make their findings available to the public and the proponent.

In addition to specialists retained to advise the Panel directly, the Panel will also retain one expert in each of the fields of metallurgy, environmental control of air and water quality, and coastal/marine ecology to work directly with public participants as a group. These latter experts will be jointly approved by the Panel and a consortium of public participants. The final report(s) of these experts will be made available to the Panel and to the public in a timely manner, consistent with the time frame of the review process.

More Information

For more information on these procedures and the Panel's review process, contact:

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Port Hardy Ferrochromium Review Panel
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NOTE: THESE PROCEDURES AND THE TIME FRAME IMPLICIT IN THEM ARE GUIDELINES ONLY. AS THE PROCESS UNFOLDS, CIRCUMSTANCES MAY REQUIRE THE PANEL TO ADJUST THESE FROM TIME TO TIME. IN THIS EVENT, THE PUBLIC WILL BE ADEQUATELY INFORMED.

PART II

OPERATIONAL PROCEDURES -- PANEL HEARINGS

INTRODUCTION AND TERMS OF REFERENCE

Sherwood Metallurgical British Columbia Corporation is proposing to develop a ferrochromium production facility near Port Hardy, British Columbia. The federal and B.C. governments have established a joint Review Panel to conduct a public review of the ferrochromium production proposal. This Panel has been constituted under the authority of the British Columbia Environment Management Act and meets the requirements of the federal Environmental Assessment and Review Process.

The mandate of the Panel is to conduct a public review of the environmental and social effects of the proposed ferrochromium plant at Port Hardy. The Panel is to identify the impacts associated with the proposal, assess their significance and investigate options for their reduction or elimination. Specifically, the Panel is to address the potential social impacts including those relating to employment, regional development, and recreation. The environmental impacts to be reviewed are to focus on construction impacts on the local ecosystem, the potential impacts of raw material storage and handling, the process technology, and all wastes or by-products associated with the Process. The Panel is to consider the proposed waste treatment and handling methods, including the use of salt water or water to air discharge for process cooling. Specific attention is to be paid to the toxicity of all materials that will be exposed to, or discharged to, the environment.

Because a large number of participants may wish to be present and heard at the Port Hardy Ferrochromium Review Panel Public Hearings, and because of the scope and complexity of the issues to be aired, the Panel has formulated a set of Procedures for these Hearings. These Procedures should help assure that the Hearings take place in an efficient, and fully equitable manner, with a maximum of mutual cooperation and courtesy.

The Panel intends to provide ample opportunity for meaningful participation by all review participants, and to facilitate their opportunity to present views, opinions and aspirations. An effort has been made to provide a single set of procedures to govern all Hearings convened by the Panel. However, at some Hearings, certain sessions will be more specific, and subject-oriented, allowing the scientific and technical information presented to be subject to detailed questioning. But in general, Hearings will be held in an informal manner to allow and encourage the maximum number of residents of a particular community to present their views about the environmental and related social considerations of the proposal.

Accordingly, these Procedures have been prepared, with the following considerations in mind:

(i) Order and efficiency are to be maintained, in an atmosphere of informality and cooperation;

(ii) The Procedures are to accommodate the general public, and reflect the views and concerns of members of the affected communities, the public, Technical Specialists, the Proponent and Governments;

(iii) The Procedures are to give an organized structure to the Hearings without making them unduly complicated or rigid;

(iv) Participants should be able to present their views in a format most favorable to their reception (assuming that proper arrangements for any specialized equipment are made with the Panel Secretary at least one week in advance of the presentation); and

(vi) Potential participants are advised that these Procedures come into effect immediately. Public notices will be issued, as required and in advance of the Hearings, to advise the public of the exact dates, times, locations and agendas of all Hearings.

These Procedures are not intended to cover every possible eventuality. They provide sufficient flexibility to accommodate any unanticipated situations that they do not address specifically. While, in general, these Procedures should be observed, the Chairman always has the discretion to amend or waive a Procedure where there are strong reasons why the purposes of the Panel's review process can better be achieved through modifications to these Procedures.

SECTION 1: PROCEDURES

1. Purposes of Procedures

The purposes of these Procedures are:

(i) to permit the assessment of the environmental and social effects of the proposed ferrochromium plant at Port Hardy, B.C. by means of procedures that are efficient and fair;

(ii) to create an informal atmosphere, but with sufficient structure to provide results that are useful to the Proponent, the participants and the Panel; and

(iii) to encourage cooperative and constructive discussion among the Proponent and participants.

2. Implementation and Interpretation

(1) These Procedures will be implemented so as to best achieve the Purposes set out in Procedure 1.
(2) All procedural matters will be considered and decided by the Chairman.
(3) Any time limit or any other provision of any Procedure may be varied by the Chairman if he is satisfied that the purposes of these Procedures would be better achieved by doing so.

3. Tone and Style

The Proponent and participants will be required to present their views and questions in a tone and style that are courteous and respectful of others. Clarity and brevity are also in the interests of meeting the objectives of the Procedures.

4. Communications

(1) Members of the Panel will avoid private oral or written communications about the substantive issues associated with the Panel review process with anyone outside the Panel's staff and the Technical Specialists.
(2) Any communication about the substance of the Panel review process received by a Panel member will promptly be committed to writing (if not already in written form) by the Panel member(s) involved, and will be made public by placing the writing on the Public File, in accordance with Procedure 5.
(3) Other than at Hearings, all communications on substantive issues associated with the Panel review process must be conducted through the Panel Secretary.
(4) Communications with Panel members about purely procedural matters, such as dates, locations, or procedures for Hearings are permitted.

5. Openness and Public File

(1) All proceedings of the Panel will be conducted in an open and public manner, with the sole exception of internal deliberations of the Panel, Panel Secretary, Panel Counsel and Technical Specialists.
(2) Copies of the Public File will be provided by the Panel Secretary for examination by any member of the public at a number of locations. A copy of the Public File will also be available at the Hearings. The Public File shall remain open for the addition of new information until 7 days following the close of all Hearings of the Panel.
(3) All information submitted to the Panel by any of the participants or the Proponent will be made public by placing it on the Public File, or otherwise as may be ordered by the Chairman.

(4) Copies of all correspondence relating to the Panel review process, and to matters of procedure will be placed on the Public File.
(5) Any submissions (other than those at a Hearing) must be in writing. No ruling will be made on any submission until a reasonable opportunity has been afforded to the Proponent and other participants to reply.

6. Technical Specialists

(1) The Panel has retained persons specialized in various disciplines as Technical Specialists. It is the role of these Technical Specialists to advise the Panel. In addition, the Panel has arranged for a second group of Technical Specialists to be engaged by means of public funds, who will be made available to all intervenors on an equal basis.
(2) Technical Specialists will review documents and submissions of the Proponent and participants, as requested by the Panel.
(3) When these reviews have been completed and presented to the Panel, they will be made public.
(4) Any participant may request a consultation with any of the second group of Technical Specialists retained under Procedure 6 (1) and all written opinions expressed by these Technical Specialists will be made public through the Panel Secretary.
(5) Consultations will be limited to advice only, as it is not the function of Technical Specialists to prepare the submission of participants.

7. Technical Sessions

The Chairman may designate certain sessions of Hearings as technical sessions. These are intended to allow the scientific and technical information presented to be subject to detailed questioning in a more structured manner than in the regular Hearings.

8. Legal Formalities

(1) Court-like procedures will not be followed at the Hearings.
(2) The swearing of oaths to tell the truth will not be required.

9. Limitation of Discussion

The Chairman may exercise his discretion to limit or exclude questions or comments which fall outside the mandate of the Panel review process, are needlessly lengthy, repetitive or are irrelevant.

10. **Hearing Notices**

Hearing Notices setting out the dates, times, and locations of Hearings will be announced by the Panel at least 30 days before the Hearings begin. Agendas for these Hearings will be made available at least 14 days before they begin.

SECTION 2: WRITTEN QUESTIONS

11. **Purpose of Written Questions**

(1) The purpose of written questions is to enable the Proponent and participants to obtain information from each other on any matter of relevance to the review which can more conveniently be provided in written form, usually prior to, rather than orally at the Hearings. The Panel will encourage full and timely responses to written questions in order to permit more informed dialogue and to reduce the time that might otherwise be required for oral questioning. This procedure takes effect immediately and continues through to the end of the hearings.
(2) Written questions should be prepared and submitted to the Proponent or to a participant if he or she requires information of such depth and complexity that oral questioning of the Proponent or another participant would be lengthy and inefficient.
(3) A copy of each written question and reply should be provided promptly to the Panel Secretary for entry in the Public File.

12. **Time Limits**

The Proponent and participants are to respond to written questions expeditiously, and where necessary, the Chairman may set time limits within which written questions may be sent by the Proponent or one participant to another and within which written replies should be provided to the sender.

13. **Confidentiality**

(1) If a recipient of a written question or a person called upon to provide an oral answer at a Hearing believes that a the answer would require the disclosure of information which he or she considers confidential, the recipient should specify in the response why confidentiality is claimed. The recipient is also expected to apply due diligence to finding an alternative, or to preparing an adequate summary of the information which he or she would be willing to disclose.

(2) The Chairman may determine that certain information should not be made public, in accordance with a procedural ruling made after consultation with the Proponent and participants.

14. **Replies**

(1) Replies to written questions should be full and responsive to the spirit of the question, and delivered within the time limit that may have been set out by the Chairman under Procedure 12. If the Proponent or a participant receives a reply that he or she considers deficient, before requesting the intervention of the Chairman, he or she shall first contact the recipient to determine whether there has been any misunderstanding and whether a more adequate reply can be provided within a reasonable period of time. If no agreement can be reached between the parties, either may refer the issue to the Chairman through the Panel Secretary. The Chairman shall resolve the issue in such manner as he considers convenient.

SECTION 3: HEARING PROCEDURES

15. **Transcripts**

All Hearings shall be recorded in their entirety so that a permanent record of the Panel's proceedings is created. A court reporter may attend a Hearing and record the proceedings in such a manner that transcripts can be prepared if required by the Chairman.

16. **Community Participation**

In general, the members of a particular community shall have a preferred opportunity to make presentations at a Hearing in their community. Non-community participants are encouraged to appear at the Hearings held in Port Hardy. In accordance with Procedure 17, the Proponent will be permitted to make a summary presentation at these Hearings.

17. **Role of Proponent**

If the Proponent attends a particular Hearing, its representatives shall have the option to summarize its proposal. The time limit for this summary shall be 20 minutes. Should the Proponent attend a particular Hearing, it will be expected to respond to questioning.

18. **Questioning and Statements**

(1) After the Proponent's presentations and any Panel questioning has been completed, each participant may ask questions about the proposal and make a brief statement. This may include any concerns or criticisms participants may have about the proposal.
(2) At the conclusion of the statement of each community participant, the Panel and Proponent may also ask questions limited to purposes of information and clarification.

(3) After the statements of all the community participants have been presented and any questioning on these has been completed, the Proponent may request permission to make a brief reply.

19. **Limitation on Questioning**

The Chairman may limit redundant questioning.

SECTION 4: TECHNICAL SESSIONS

20. **Intention to Participate**

(1) Anyone wishing to make a presentation at a technical session of a Hearing shall give notice of his or her intention to participate to the Panel Secretary, not less than 7 days before the opening of the Hearing. Any person providing timely notice of intention to participate will be included on a list of registered participants.
(2) If time permits, after all registered participants have been heard at a technical session of a Hearing, participants not on the list may also be heard.

21. **Participants May be Questioned**

The Proponent and all participants may be asked by a Panel member to respond to questions relating to matters relevant to the review. Procedures 19 to 27 describe the manner in which this questioning will be conducted.

22. **Questioning**

(1) At technical sessions, the questioning of the Proponent and participants by Panel, Proponent, Technical Specialists, Panel Counsel and intervenors may be to obtain further information or explanation, or to question the correctness of facts or the validity of opinions presented.
(2) Questioning does not include making critical speeches or arguments. Those wishing to present rebuttal or argument may register with the Panel Secretary and be scheduled for a brief rebuttal following questions on a given presentation.

23. **Main Presentations**

(1) The Proponent and participants may make main presentations of a technical or non-technical nature.
(2) Anyone submitting scientific or technical facts will be subject to extensive, detailed questioning. Others may be questioned informally for purposes of clarification, at the discretion of the Chairman.

24. **Pre-Filing Presentations**

All participants are encouraged to pre-file any statements of scientific or technical fact or expert opinion by sending a copy of this evidence to the Panel Secretary. These should be received at least 14 days before the commencement of the Hearings. At Hearings that address technical evidence, the sequence of presentations may be determined by the order in which these written presentations are received by the Panel Secretary. The Panel Secretary shall arrange to have copies of these presentations delivered to registered participants in advance of the Hearings.

25. **Sequence of Presentations**

(1) Presentations will occur at technical sessions of Hearings in three phases: Opening Statements, Main Presentations, and Final Statements. During each phase, presentations will be made in the following sequence: Proponent, the Panel's Technical Specialists, the participants' Technical Specialists, and other participants in an order that reflects the order in which written evidence has been received by the Panel Secretary.
(2) Each person may be questioned immediately after his or her presentation.
(3) Where circumstances require it, the Proponent or any participant may request that the Chairman change the order of presentations and he may make such changes to the sequence of questioning or presentations as he may consider appropriate.

26. **Opening, Main, and Final Statements**

(1) The Proponent and each participant intending to present scientific or technical information may request permission to make a short introductory statement to inform the Panel of the nature and structure of this information.
(2) After all opening statements are completed, each party will be permitted to present both technical and non-technical facts or information on the proposal.
(3) Each party may make a final statement, after all main presentations are completed, provided that he or she does not repeat what he or she has already said in the Hearing. Because final statements will not be subject to questioning, they may not contain any new scientific or technical information. They shall also be as succinct as circumstances allow. The Chairman may impose time limits in the interests of fairness to all participants. Participants and the Proponent may expand upon their oral statement in writing received by the Panel Secretary within 7 days of making their oral statement.

27. **Presentation Groups**

(1) More than one individual may participate in a presentation to ensure that the Panel and questioners receive information from the most qualified person.
(2) Where a presentation is made by a number of individuals together, each speaking on a particular area of expertise, the Proponent or a participant may direct his or her questions to any individual in the group presenting evidence.
(3) If that person is unable to answer the question, he or she may refer it to another member of the group for reply.

28. **Disagreements regarding Questioning**

If the Proponent or a participant refuses to answer a question, the Panel may take that factor into account in assessing the weight to give to his or her presentation.

29. **Adjournments**

The Chairman will rule on all requests for adjournments.

SECTION 5: GLOSSARY OF TERMS

Notice Written announcement of information related to the Hearings.

Panel The Port Hardy Ferrochromium Plant Review Panel consisting of Mr. Bryan Williams, Q.C. (Chairman), Mr. George Davies, P. Eng., and Dr. Paul West.

Panel Secretary The person who administers the Panel's Office and assists it in all the administrative aspects of the review process. The Panel Secretary is Mr. Ken Youds. The Panel Office address is P.O. Box 42087, Oak Bay R.P.O., 2200 Oak Bay Avenue, Victoria, British Columbia V8R 6T4. The telephone numbers are (604) 949-9898 or (604) 370-1000. The Fax number is (604) 595-8265.

Participants Intervenors, Technical Specialists, individuals or groups who make informal or formal presentations at Hearings.

Proponent The company proposing to construct the ferrochromium plant, Sherwood British Columbia Metallurgical Corporation.

Public File The Public File will contain all information submitted in relation to the Panel review process and will be available for public inspection at a number of public reference centres as well as at all Hearings.

Questioning Oral questions put to participants which, if relevant, must be answered as fully as possible.

Registered Participant Any individual or group, who by notifying the Panel Secretary, has identified an interest in taking an active role at the Hearings.

Relevance A question or statement is relevant if it relates to a matter which is before the Panel for consideration, either because it is part of the proposal of the Proponent, or because it is part of the comment on the proposal by one of the other participants, provided always that it falls within the general mandate and scope of the Panel review process.

Statement The presentation, orally or in writing, or conclusions, recommendations, requests, concerns or viewpoints.

Written Questions A written question addressed by one participant to another, or by a participant to the proponent, or by the proponent to a participant, in which a written reply is sought. The Question may be about any relevant matter such as the way in which certain numbers were calculated, the basis for certain statements, techniques used to obtain scientific data, and so on.

APPENDIX C

BACKGROUND REFERENCE DOCUMENTS

During the review, the Panel encountered a variety of previously published documents of potential relevance to the assessment of the project in question. These were not submitted as direct files of this particular review. Moreover, these were judged to already be in the public domain and protected from photocopying by copyright law.

These background reference documents are listed in a numerical sequence based upon the order in which they were obtained by the Panel.

BACKGROUND REFERENCE DOCUMENTS

1. British Columbia Workers Compensation Board. Industrial Health and Safety Regulations. 1980

2. British Columbia Workers Compensation Board. Industrial First Aid Regulations. 1979 (reprinted 1989).

3. British Columbia Workers Compensation Board. Workplace Hazardous Materials Information System.

4. British Columbia, Prov. of. Archaeological Resource Management Handbook. Ministry of Municipal Affairs, Recreation and Culture. Victoria, 1989.

5. Ibid. British Columbia Archaeological Impact Assessment Guidelines. Ministry of Municipal Affairs, Recreation and Culture. Victoria, 1989.

6. Canada. Initial Assessment Guide: Federal Environmental Assessment and Review Process. F.E.A.R.O. Ottawa, 1986.

7. Canada. Environmental Assessment Panels: Procedures and Rules for Public Meetings. Federal Environmental Assessment Review Office. Ottawa, 1985.

8. Ibid. Public Review: neither Judicial, Nor Political, But an Essential Forum for the Future of the Environment. F.E.A.R.O. Ottawa, 1988.

9. Beaufort Sea Environmental Assessment Panel. Procedures For General Sessions. 1983.

10. United States Environmental Protection Agency. Smelting and Slag Processing. E.P.A. Effluent Guidelines Division. Washington, D.C. 1974.

11. Ibid. Noncarcinogenic Effects of Chromium: Update to Health Assessment Document. Office of Health and Environmental Assessment. Washington, D.C. 1989. (Also entered as Exhibit 45).

12. Bradford Enercon. Industrial Insulation for the 90's.: Design Guide. New Westminster, B.C.

13. Ibid. Enerok 1200, Industrial Insulation. New Westminster, B.C.

14. Ibid. Excellence in Insulation (miscellaneous fact sheets). New Westminster, B.C.

15. Port Hardy Economic Development Committee. Brief Summarizing the Economic History, Objectives, and Issues of the Port Hardy Area. (folio of various extracts and reports.)

16. U.S. E.P.A. Health Assessment Document for Chromium. Washington, D.C. (copies loaned to P. West and Andrew Hazelwood in June 1990)

17. U.S. Public Health Service. Toxicological Profile for Chromium. Washington, D.C. 1989.

18. Washington State, Dept. of Ecology. Sediment Management Standards. Olympia, Wash. 1990

19. British Columbia, Ministry of Environment. Coquitlam-Pitt River Area Burrard Inlet Water Quality Assessment and Objectives. Water Management Branch, Victoria, B.C. 1990.

20. National Oceanic and Atmospheric Administration. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. National Ocean Service, Seattle, Washington. 1990.

21. Environment Canada. Metal Mining Liquid Effluent Regulations and Guidelines.

22. Transport Canada. User Requirements Study: Port Hardy Deep Sea Port Facility, Final Report. prepared by Sandwell Swan Wooster Inc. Vancouver, B.C. 1988.

23. Environment Canada. Distribution and Environmental Impact of Selected Benthic Contaminants in Vancouver Harbour, British Columbia: 1985 - 1987. prepared by D. Goyette & J. Boyd. 1989.

24. Brown, R.M. & T.M. Rankin. Persuasion, Penalties and Prosecution: The Treatment of Repeat Offenders under British Columbia's Occupational Health and Safety and Pollutional Control Legislation. Faculty of Law, University of Victoria. 1988.

25. U.S. E.P.A. Engineering and Cost Study of the Ferroalloy Industry. prepared by Dealy and Killin. Office of Air and Waste Management, North Carolina. 1974.

26. Office of the Federal Register National Archives and Records Administration. Code of Federal Regulation: 40 - Protection of Environment. 1987.

27. Port Hardy Ferrochromium Review Panel. Index to Proceedings of October 4th to 18, 1990. Victoria, B.C. 1990.

28. British Columbia. Waste Management Act: Special Waste Regulation. 1988.

29. Ibid., Ministry of Environment. Pollution Control Objectives for Municipal Typle Waste Discharges in British Columbia. Queens Printer, Victoria. 1989.

30. Ibid. Pollution Control Objectives for The Mining, Smelting and Related Industries of British Columbia. Queens Printer, Victoria. 1979 (reprinted 1989).

APPENDIX D

FILE REGISTER

(copy of original ledger)

PORT HARDY FERROCHROMIUM REVIEW PANEL

FILING SYSTEM

1. Each item of public record is assigned a number, as part of a comprehensive sequence that includes all items received. Normally, panel replies to submissions will be separately filed, but replies to some specific letters will be assigned a number code to correspond to the correct incoming letter.

2. Each item is recorded in the file register, which must be kept up-to-date and must be available for public scrutiny, according to the EARP O-i-C.

3. Items are classified into one of the following source-oriented categories:

   a) Public Submissions; "PS":

      Includes items coming from a member of or group of the public. Includes municipalities and native associations.

   b) Panel Documents; "Panel":

      Public items originating with the panel or panel's consultants.

   c) Proponent Submissions; "Pro":

      Items originating with the proponent and/or proponents' consultants, advisors, etc.

   d) Government Submissions; "Govt":

      Items originating with an office of the provincial or federal government and directly related to this review process.

   e) Background Information; "BI":

      Items that are or might be relevant but have been separately produced (i.e. not during or for this review process), usually prior to the establishment of this review panel. This includes the terms of reference and mandate documents (statutes, etc.) for the panel.

4. Each item is catalogued in the sequence it is received, with regard to the total file system and the specific file category.

Example: item "32 - Govt.4"

- this is the thirty-second item on file
- it is a government submission
- it is the 4th submission from government

* * *

FILES REGISTER

Port Hardy Ferrochromium Review Panel

NAME	Affiliation and/or Address	DATE RECEIVED	SEQ NO	FILE	MAIL LIST	REPLY	COPIES	CIRCULATE
AUSTIN, W.M.C.	KHOYATAN MARINE LAB	JAN 24/90	1	PS.1	✓	✓	✓	✓
LAMSA, et al.	CONCERNED RESIDENTS OF NORTH ISLAND	JAN 24/90	2	PS.2	✓	✓	✓	✓
WILLIAMS, B	PANEL	FEB 2/90	3	Panel.1	✓	N/A	✓	✓
WEYNER, T	Box 1070, P.H. V0N 2P0	FEB 6/90	4	PS.3	✓	✓	✓	✓
BURGESS, J	Box 1333, P.H. " "	FEB 8/90	5	PS.4	✓	✓	✓	✓
BURGESS, K	" " " "	FEB 8/90	6	PS.5	✓	✓	✓	✓
YOUNG, K	Box 70 SCINTILLA V0N 3E0	FEB 8/90	7	PS.6	✓	✓	✓	✓
SKELLY, R	747 Confederation Bldg, H.f.C. Ottawa K1A 0H5	FEB 8/90	8	PS.7	✓	✓	✓	✓
DALON, R	MOE	" /90	9	GOVT.1	✓	N/A	✓	✓
WEDDING, J	% Davis + Co., R Snow	JAN 24/90	10	PRO.1	✓	N/A	✓	✓
WEDDING, J	WASTE MGMT APPLICATIONS	JAN 30/90	11	PRO.2	✓	N/A	✓	✓
SCOTT, P	FEARO, 510-750 West Cambie, Vanc. V6B-2P2	JAN 22/90	12	GOVT.2	✓	N/A	✓	✓
ALFRED, P	NIMPKISH BAND COUNCIL Box 210 Alert Bay V0N-1A0	FEB 13/90	13	PS.8	✓	✓	✓	✓
ROBERTS, R	Nathan Roberts + Lee: 10th floor, 100 W. Pender Vancouver V6B-1R6	FEB 13/90	14	PS.9	✓	PHONE	✓	✓
ASPINALL, C	Suite 302, 1224 Homer St. Vanc. V6B-2X5	"	15	PRO.3	✓	N/A	✓	✓
LAURIE, REV. B	Box 1260 Port Hardy V0N-2P0	"	16	PS.10	✓	✓	✓	✓
LEE, A.	P.O. BOX E7, MILLBAY V0R 2P0	"	17	PS.11	✓	✓	✓	✓
RUSSELL, M	Box 164 P.H. V0N-2P0	"	18	PS.12	✓	✓	✓	✓
SAXON, B	General Delivery, P.H. V0N-2P0	"	19	PS.13	✓	✓	✓	✓
SMITH, K	Box 951, P.H. V0N-2P0	"	20	PS.14	✓	✓	✓	✓
LEBLANC, A	Box 982, P.H V0N-2P0	"	21	PS.15	✓	✓	✓	✓
BURGESS, J	(noted above)	"	22	PS.16	✓	✓	✓	✓
HOPKINS, E		"	23	PS.17	✓	✓	✓	✓
BURGESS, K	(noted above)	"	24	PS.18	✓	✓	✓	✓
O'CONNER, L	Box 335, P.H. V0N-2P0	"	25	PS.19	✓	✓	✓	✓
CLAUTEN, R	Box 7, P.H. V0N-2P0	"	26	PS.20	✓	✓	✓	✓
LIEPINS, N	Box 296, P.H. V0N-2P0	"	27	PS.21	✓	✓	✓	✓
CONCERNED RES.	B. Lamsa (?) Box 2218, P.H, V0N 2P0	"	28	PS.22	✓	N/A	✓	✓
WEDDING, J	(noted above)	FEB 19/90	29	PRO.4	✓	N/A	✓	✓
NEW JERSEY D.H	(N.A.)	"	30	BI.1	■	N/A	✓	✓
FEARO/ROBINSON	(noted above)	"	31	GOVT.3		N/A	✓	✓
HAGEN, S	MoR DEVELOPMENT	JAN 22/90	32	GOVT.4	✓	N/A	✓	✓
EVERSON, J	WEST EC. DIVERSIFICATION	FEB 19/90	33	GOVT.5	✓	N/A	✓	✓
AMBERS, B	KWAKIUTL DIST. COUNCIL	"	34	PS.23	✓	N/A	✓	✓
MCCOLL, D	MIN. of CROWN LANDS	"	35	GOVT.6		N/A	✓	✓
VEITCH, E	MIN of REGIONAL DEVELOPMENT	"	36	BI.2			✓	✓
CPAA NANAIMO	46 Roberts St., Nanaimo V9T-2S4	FEB 20/90	37	BI.3	✓		✓	✓
MORELL	(N.A)	"	38	BI.4	(N.A)		✓	✓
WRIGHT ENG. LTD.	(N.A)	"	39	BI.5	(N.A)		✓	✓
MILLEN, J	ENVIRONMENT CANADA	"	40	BI.6	✓		✓	✓
AUSTIN, W.M.C	(noted above)	"	41	BI.7	✓		✓	✓
WEST. DIVERSIFICA	R. Dodson, Box 49276, Bentall 2 1200-1055 Dunsmuir St., Vanc. BC V7X-1L3	"	42	RI.8	✓		✓	✓

NAME	Affiliation +/or Address	DATE RECEIVED	SEQ. NO.	FILE	MAIL LIST	REPLY	COPIES	CIRCULATED
LANDON, DAVE	DAVE LANDON MOTORS LTD., MARKET ST. BOX 67, PORT HARDY	FEB 22/90	44	PS.25	✓	✓	✓	✓
AITKEN, NEIL	BOX 178 GABRIOLA, B.C. V0R 1X0	FEB 22/90	45	PS.26	✓	✓	✓	✓
PORT HARDY MAYOR + COUNCIL	A. Huddleston; Box 68, P.H. V0N-2P0	FEB 22/90	46	BI.9	✓	N/A	✓	✓
Reynolds, J. Hon	Minister of Environment (BC)	"	47	Govt.7	N/A	N/A	✓	✓
Rescan Environ. Consultants.		Feb 25/90	48	BI.10	N/A	N/A	✓	✓
BROWN, DIANE	SOUTH END CITIZENS ASSOC. 87 NICOL STREET NANAIMO V9R 4S7	FEB 27/90	49	PS.27	✓	✓	✓	✓
CRAWFORD, B.M.	BOX 1784 PORT HARDY V0N 2P0	FEB 27 90	50	PS.28	✓	✓	✓	✓
BURGESS, K	(noted above)	FEB "	51	PS.29	✓	✓	✓	✓
SHERWOOD	INITIAL SUB	FEB 28/90	52	PRO.5	✓	N/A	✓	✓
MAYER, CHARLES	Minister, Western Ec. Diversification	MAR.1/90	53	GOVT.8	✓		✓	✓
BOUCHARD, L	Minister, Environment (Canada)	MAR 1/90	54	GOVT.9	✓		✓	✓
BULLETINS #1+2		"	55	PANEL.2		N/A	✓	✓
SHERWOOD PROJET	(N.A.)	"	56	BI.17		N/A	✓	✓
QUITTENTON, ET AL	(N.A.)	"	57	BI.12		N/A	✓	✓
SHERWOOD	(N.A.)	"	58	BI.13			✓	✓
INDUSTRIAL DEV.	NEWS RELEASE (N.A.)	"	59	BI.14			✓	✓
HIGGINS, R.J.	Fisheries + Oceans, 3225 Stephenson Pt. Nanaimo	"	60	BI.15	✓		✓	✓
MILLEN, J	Environment Canada Mapleview 1181, Bank Royal, West Mall. V7T-1A2	"	61	BI.16	✓		✓	✓
HEARTWELL, C	Western Ec. Diversification	"	62	BI.17	✓		✓	✓
SHERWOOD	(N.A.). C/o Davis + Co.	"	63	BI.18	✓		✓	✓
S.P.E.C.		"	64	BI.19			✓	✓
S.P.E.C.		"	65	BI.20			✓	✓
SHERWOOD	c/o Davis + Co.	"	66	BI.21	✓		✓	✓
SKELLY, R	(noted above)	"	67	PS.30	✓	✓	✓	✓
BURGESS, K	(noted above)	MAR 5	68	PS.31	✓	✓	✓	✓
RUSSELL, M.	(noted above)	"	69	PS.32	✓	✓	✓	✓
LIEPINS, N	(noted above)	"	70	PS.33	✓	✓	✓	✓
ROBERTS, K	(noted above)	MAR 7	71	PS.34	✓	✓	✓	✓
PANEL	(N.A.)	MAR 7	72	PANEL.3			✓	✓
BURGESS/FEARD	(noted above)	"	73	PS.35			✓	✓
SKELLY, R	(noted above)	MAR.9	74	PS.36	✓		✓	✓
LEE, L	Seaweb J.E. Inc. Box 87, Mill Bay V0R-2P0	"	75	PS.37	✓	✓	✓	✓
ROBERTS, K	(noted above)	MAR.16	76	PS.38			✓	✓
SHERWOOD	INITIAL SUB - SUPPLEMENTAL	"	77	Pac.6			provided	✓
[illegible]	Pamphlets	"	78	Rec.7			"	✓
Kinds - PANEL	(N.A.)	Mar. 19	79	Panel.4			✓	✓
BULLETIN #3	(N.A.)	"	80	PANEL.5			✓	✓
Wilson	R.R.1, Genoa Bay Rd. Duncan V9L-1M3	Mar. 13	81	PS.39	✓	✓	✓	✓
Lamont, Bryt	Box 1333 P.H., V0N-2P0	Mar. 20/90	82	PS.40	✓	✓	✓	✓
COON, L. MICHAEL	Ministry of Agricult. + Fisheries, Victoria	Mar 26/90	83	GOVT.10	✓		✓	✓
ASPINALL, C.	(noted above)	"	84	PRO.8	✓	N/A	✓	✓
STEVENSON, L.	P.O. BOX 1422 PORT HARDY	"	85	PS.41		✓	✓	✓
OLDHAM, G.E.	Waste Management Branch, MoE.	Mar 27/90	86	GOVT.11	✓	N/A	✓	✓

NAME	Affiliation c/or Address	DATE RECEIVED	SEQ NO.	FILE	MAIL LIST	REPLY	COPIES	CIRCULATED
PRITCHARD, H	Box 2115 PORT HARDY	Mar. 27/90	87	PS·42	✓	✓	✓	✓
SHERWOOD	11 x 17 SCHEMATIC DRAWINGS SECOND SUPPLEMENTAL	"	88	PRO·9	—	N/A	✓	✓
SHERWOOD	THIRD SUPPLEMENTAL SUBMISSION (HIGHLETER)	"	89	PRO·10	✓	N/A	✓	✓
RANKIN, M	CONFLICT OF INT. STATEMENT	"	90	PANEL·6	✓	N/A	✓	✓
LYSNE, N.	Box 1620 P.R.	MAR. 31/90	91	P.S.·43	✓	✓	✓	✓
POPOVICH, G.	Box 2, ALBERT BAY - MAINE	"	92	PS.44	✓	✓	✓	✓
SANBORN, A.	Box 384, ALBERT BAY VON 1A0	"	93	PS·45	✓	✓	✓	✓
BRAUER, K.	Box 128, Sointula VON-3E0	"	94	PS.46	✓	✓	✓	✓
TRACY, H.M.	Box 151, SOUTH HEDDINGTON, ONT.	"	95	PS·47	✓	✓	✓	✓
SKINNER, C.	Box 142, ALBERT BAY, VON 1A0	"	96	PS·48	✓	✓	✓	✓
LIQUORI, N.	NO ADDRESS ON SUBMISSION	"	97	PS.49	—		✓	✓
ROBINSON, B.	Box 884, PORT H.	"	98	PS·50	✓	✓	✓	✓
KROEKER, T.	Box 1973, P.H.	"	99	PS·51	✓	✓	✓	✓
MIDDLESTAN, D.	Box 977, P.H.	"	100	PS·52	✓	✓	✓	✓
CRYDER, J+C	Box 2616, P.H.	"	101	PS·53	✓	✓	✓	✓
GRANT, S.	Box 1744, P.H.	"	102	PS·54	✓	✓	✓	✓
LIEPINS, N.	(noted above)	"	103	PS·55	✓	✓	✓	✓
LIQUORI, MRS. P.	Box 1916, P.H.	"	104	PS·56	✓	✓	✓	✓
CARTWRIGHT, D.	Box 872, PH.	"	105	PS·57	✓	✓	✓	✓
REINER, A.E.	Box 88, P.H.	"	106	PS·58	✓	✓	✓	✓
HEAL, TOM	Box 1468, PH	"	107	PS·59	✓	✓	✓	✓
THORNTON, E	Box 1415, PH	"	108	PS·60	✓	✓	✓	✓
PEDERSEN, D.	Box 2517, PH	"	109	PS·61	✓	✓	✓	✓
NICHOLSON, B.	Box 2354, PH.	"	110	PS·62	✓	✓	✓	✓
UNIDENTIFIED		"	111	PS·63	—	N/A	✓	✓
STONE, S	Box 1178, P.H.	"	112	PS·64	✓	✓	✓	✓
BURGESS, K	(noted above)	"	113	PS·65	✓	✓	✓	✓
RUSSELL, MARY	(noted above)	"	114	PS·66	—	✓	✓	✓
ELLINGSON, J.	Box 275, P.H.	"	115	PS·67	✓	✓	✓	✓
WELCHMAN, B.	Box 692, P.H.	"	116	PS·68	✓	✓	✓	✓
MIDDLESTON, A.	(noted above)	"	117	PS·69	✓	✓	✓	✓
C.R.N.I	(noted above)	"	118	PS·70	—	✓	✓	✓
AUTHOR UNIDENTIFIED		"	119	PS·71	—		✓	✓
P.H.EC.DEV.COM.	District of P.H. Box 168	"	120	PS·72	—	✓	✓	✓
P.H.EC.DEV.COM.	" " " "	"	121	PS·73	—	N/A	✓	✓
LEBEAU, A.	Box 982 P.H.	"	122	PS·74	✓	✓	✓	✓
CLEGG, M.	6340 BEAVER HARBOUR RD. BOX 841, P.H.	"	123	PS·75	✓	✓	✓	✓
MACKAY, I.	SITE 2, BERRY PT., GABRIOLA H. V0R 1X0	"	124	PS.76	✓	✓	✓	✓
FURNELL, G.	P.O. Box 728 Port McNeill V0N-2R0	"	125	PS·77	✓		✓	✓
WOOLDRIDGE, W	Box 487 PORT MCNEILL V0N 2R0	"	126	PS·78	✓	✓	✓	✓
SANDBORN, C	West Coast Environ Law Soc.	"	127	PS·79	—	✓	✓	✓
SHERWOOD	c/o Davis + Co. Rod Simon EIGHTH SUPPLEMENTAL	"	128	PRO·11	—	-	✓	✓
NIMPKISH BAND	(noted above)	"	129	PS·80	-	✓	✓	✓

NAME	Affiliation +/or Address	DATE RECEIVED	SER NO	FILE	MAIL LIST	REPLY	COPIES	CIRCULA
HILLEN, J.	NOTED PREVIOUSLY	APRIL 10/90	130	GOVT.12	✓	✓	✓	✓
YOUDS - PANEL	"	"	131	PANEL 7	✓	N/A	✓	✓
GRANT, B	NOTED PREVIOUSLY	"	132	PS.81	✓	✓	✓	✓
PENNIMPEDE, H	Box 474, P.H.	"	133	PS.82	✓	✓	✓	✓
HALE, P	Box 65 COAL HARBOUR	"	134	PS.83	✓	✓	✓	✓
DIMMOCK, M+J	Box 84 F.H.	"	135	PS.84	✓	✓	✓	✓
BURGESS, K	NOTED PREVIOUSLY	"	136	PS.85	✓	✓	✓	✓
PRITCHARD, H	Box 2115, P.H.	"	137	PS.86	✓	✓	✓	✓
PRITCHARD, C	"	"	138	PS.87	✓	✓	✓	✓
WOOLDRIDGE, R.	Box 101 PORT McNEILL	"	139	PS.88	✓	✓	✓	✓
ROGERS, L	Box 214 SOINTULA, B.C.	"	140	PS.89	✓	✓	✓	✓
OGDEN, D.	Box 210 SOINTULA, B.C.	"	141	PS.90	✓	✓	✓	✓
PAGE, J.	Box 248, PORT McNEILL	"	142	PS.91	✓	✓	✓	✓
FRANKLAND, R.	GENERAL DELIVERY, ALERT BAY VON 1A0	"	143	PS.92	✓	✓	✓	✓
LUDMS, RUTH	C.A.F. 9/0 J. KIPP Box 986, STN. A, NANAIMO V9R 5N2	"	144	PS.93	✓	✓	✓	✓
AUSTIN, BILL	NOTED PREVIOUSLY	"	145	PS.94	✓	✓	✓	✓
Cadwallader, J.T.	Box 8, P.H.	"	146	P.S.95	✓	✓	✓	✓
McDowell, L.	Box 365, Sointula	April 17	147	PS.96	✓	✓	✓	✓
Roberts, K.	Nadden, Roberts + Lees (noted previously)	"	148	PS.97	✓	✓	✓	✓
Williams, B.	(Issues Ltd.)	"	149	PANEL.8	✓	N/A	✓	✓
YOUDS	BULLETIN #4	"	150	PANEL.9	✓	N/A	✓	✓
Pate, H + A.	Box 638, Bl.	April 20	151	PS.98	✓	✓	✓	✓
Weymer, T.	Box 1070, P.H	"	152	PS.99	✓	✓	✓	✓
YOUDS	OPEN LETTER/GROUPS - EXPERTS	April 18	153	PANEL.10	✓	—	✓	✓
SHERWOOD		April 17	154	PRO.12	✓	—	✓	✓
YOUDS	BULLETIN # 5	April 20	155	PANEL.11	✓	—	✓	✓
NIKOLIC, N+A	Box 361, PORT H.	APRIL 21	156	PS.100	✓	✓	✓	✓
NOLAN, JAMES	Box 1267, PORT McNEILL	"	157	PS.101	✓	✓	✓	✓
EMERSON, B.	MIN. OF HEALTH / COURTNEY	"	158	GOVT.13	✓	✓	✓	✓
PANEL	ROCK WOOL PRODUCTION	APRIL 24	159	PANEL.12	✓	—	✓	✓
SHERWOOD	KEY ISSUES ADDRESSED	"	160	PRO.13	✓	—	✓	✓
CHROMIUM	DATA	"	161	BI.22	✓	—	✓	✓
SMITH, MR+MRS. W	Box 2282, P.H.	"	162	PS.102	✓	✓	✓	✓
EAGLE, SYLVIA	Box 1578, P.H.	"	163	PS.103	✓	✓	✓	✓
FIELD, ROBERT	Box 248, SOINTULA	"	164	PS.104	✓	✓	✓	✓
DALON, R.L.		"	165	GOVT.14	✓	N/A	✓	✓
DAVIS & COMPANY		"	166	PRO.14	✓	—	✓	✓
ROBERTS, KIM		"	167	PS.105	✓	✓	✓	✓
RANKIN, M.			168	PANEL.13	✓	—	✓	✓
WILLIAMS, B.			169	PANEL.14	✓	—	✓	✓
YOUDS, KEN	report distribution (Appendix 1, 2, 3)		170	PANEL.15	✓	—	✓	✓
YOUDS	INFO REQUESTS TO VARIOUS AGENCIES (Govt letter + attachments)		171	PANEL.16	✓	—	✓	✓
YOUDS	GROUPS LIST		172	PANEL.17	✓	—	✓	✓

NAME	Affiliation +/or Address	DATE RECEIVED	SER NO	FILE	MAIL LIST	REPLY	COPIES	CIRCULATED
SHERWOOD	5th SUPPLEMENTAL	MAY 2/90	173	PRO·15	✓	n/a	proponent distributed	✓
CARLSEN, Tanya	NO ADDRESS GIVEN	MAY 7/90	174	PS·106	—	—	✓	✓
Snow, R.	Davis + Co, 2800 Park Place, 666 Burrard St	May 4/90	175	PRO. 16	v	—	✓	✓
ROBERTS, K.	NADER, ROBERTS & LEE	MAY 7/90	176	PS·107	✓	✓	✓	✓
SADDON, C.	WEST COAST ENVIRONMENTAL LAW ASSOC.	MAY 7/90	177	PS·108	✓	—	✓	✓
YOUDS	PANEL	MAY 10/90	178	PANEL·18	—	—	✓	✓
STEVENSON, DON	Box 1622, P.H.	"	179	PS·109	✓✓	✓	✓	✓
P.H. EL. DEV. COM.	NOTED AGENDUM	"	180	PS·110	✓	✓	✓	✓
ROBERTSON, RB	NO ADDRESS GIVEN	"	181	PS·111	—	—	✓	✓
LIEPINS, NOREEN	ABOVE	"	182	PS·112	✓	✓	✓	✓
SHERWOOD	EIS		183	PRO·17	—✓	—	✓ By proponent	✓ (by proponent)
ANDERSON, BARB	Box 884, P.H.	MAY 10/90	184	PS·113	✓	✓	✓	✓
HANSEK, LINDA	Box 249, P.H. · CHAMB. OF COMMERCE	"	185	PS·114	✓✓	✓	✓	✓
ALFRED, PAT	NEMPKISH BAND COUNCIL	MAY 14/90	186	PS·115	✓	—	✓	✓
KARLSEN, ERIK	MUNICIPAL AFFAIRS	"	187	GOVT·15	✓	—	✓	✓
PENNIMPEDE, F.	Box 474, P.H.	MAY 15/90	188	PS·116	✓	✓	✓	✓
P.H. ECONOMIC DEV. COM.		MAY 15/90	189	PS·117	✓	—	✓	✓
LUX, A.R. W.C.B.	320 COOK ST. VICTORIA WORKERS COMPENSATION BOARD	MAY 16/90	190	GOVT·16	✓ ?	—	✓	✓
APLAND, B.		"	191	GOVT·17	✓	—	✓	✓
QUITENTON, R.C.	Box 145, Bowser, B.C. V0R 1S0	"	192	PS·118	✓		✓	✓
BEAVER, KATE	Box 128, SOINTULA (U.F.A.W.J)	MAY 17/90	193	PS·119	✓	—	✓	✓
WASDEN, BILL	Box 90, ALERT BAY	"	194	PS·120	✓	—	✓	✓
HARRIS, RALPH	M.I.E.P.S. Box 181, SOINTULA	"	195	PS·121	✓✓	—	✓	✓
BECKER, B.	SHERWOOD. P.H.	MAY 18/90	196	PRO.18	✓✓	.	✓	✓
PANEL	MIN. OF HEALTH - INFO. REQUEST	—	197	PANEL·19	✓	—	✓	✓
PANEL	VIDEO TAPES	—	198	PANEL·20	—	—	✓	✓
PLECAS, R.S.	Ministry of Rg'l + Ec. Development	MAY 18/90	199	GOVT. 18	✓	—	✓	✓
PANEL	BULLETIN #6	—	200	PANEL·21	—		✓	✓
Roberts, K	Nader, Roberts + Lee	May 23/90	201	PS 122	—	N/A	✓	✓
Moss, M.	P.H. Marine Resource Management Security 9300 Trumpeter Road, P.H. V0N 2P0 961-M12	"	202	PS 123			✓	✓
Dodson, R.	Western Ec. Diversification	May 25/90	203	Govt. 19	—	✓	✓	✓
REEDER, STU	B.C.W.F. 102-6070 200TH ST. LANGLEY V3A 1R6	"	204	PS·124	✓	✓	✓	✓
LANDON, DAVE	JUST PEOPLE / Box 67 P.H.	"	205	PS·125	✓	✓	✓	✓
YOUDS	RE: EXHIBITS	—	206	PANEL·22	—	—	✓	✓
SNOW, R.	DAVIS + COMPANY	"	207	PRO·19	—	—	✓	✓
TURNER, MRS. T.	Box 168 SOINTULA V0N 3E0		208	PS·126	✓	✓	✓	✓
KEHL, C·G.	B·C HYDRO	JUNE 5/90	209	GOVT·20	✓	—	✓	✓
MINDSON, J.G.	WORKERS COMP. BOARD	"	210	GOVT·21	✓	—	✓	✓
ROBERTS, K.	COPY - orig addressed to Davis & Co.	JUNE 6/90	211	PS·127	✓	—	✓	✓
LANDON, DAVE	JUST PEOPLE	"	212	PS·128	✓		✓	✓
PANEL / RANKIN	MR		213	PANEL·23	—	—	✓	✓
PANEL / RANKIN			214	PANEL·24	—	—	✓	✓
WOLD, DORIS	QUATSINO, B.C. GEN. DELIVERY V0N 2V0		215	PS·129	✓	✓	✓	✓

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ROUECHE, L.R.	B.C. FERRY CORP.	JUNE 14/90	216	GVT. 22	✓	—	✓	✓
DENHOFF, ERIC	NATIVE AFFAIRS	"	217	GVT. 23	✓	—	✓	✓
YOUDS	LETTER TO BECKER	—	218	PANEL. 25	—	—	✓	✓
PANEL	HEARINGS SCHEDULE / OPERATIONAL PROCEDURES	—	219	PANEL. 26	—	—	✓	✓
YOUDS	letter to Dryden.	June —	220	PANEL. 27	—	—	✓	✓
Roberts	(above)	June 9/90	221	PS. 130	✓	✓	✓	✓
YOUDS	LETTER TO SNOW	"	222	PANEL. 28	—	—	✓	✓
HUDDLESTON, A	DISTRICT OF PORT HARDY	JUNE 13/90	223	PS. 131	✓	✓	✓	✓
LEMMON, WM. A.	EMR 1988 CHROMIUM REVIEW	JUNE 14/90	224	PAN/EX. 1	✓	—	✓	✓
ROBERTS, K.	(ABOVE)	JUNE 18/90	225	PS. 132	✓	—	✓	✓
YOUDS	LETTER TO R. SNOW	—	226	PANEL. 29	—	—	✓	✓
SHAFFER, M.	DEFICIENCY INFORMATION	"	227	PAN/EX. 2	✓	—	✓	✓
CHAPMAN, P	EVS CONSULTANT	"	228	PAN/EX. 3	✓	—	✓	✓
LEWIS, A.G.	DEFICIENCY	"	229	PAN/EX. 4	✓	—	✓	✓
BRIMACOMBE, J.K.	DEFICIENCIES	"	230	PAN/EX. 5	✓	—	✓	✓
SAGERT, P	CIRRUS CONSULTANT	"	231	PAN/EX. 6	✓	—	✓	✓
LEHMAN, WM. A.	NAPIER + CO.	"	232	PAN/EX. 7	✓	—	✓	✓
YOUDS.	NOTICE TO PARTICIPANT GROUPS	—	233	PANEL. 30	—	—	✓	✓
SANDISON, C	HEARING PARTICIPATION	"	234	PS. 133	✓	—	✓	✓
YOUDS	LETTER TO DR. J. WARD	—	235	PANEL. 31	—	—	✓	✓
BRAUER, K	HEARINGS SCHEDULE OPPOSITION	"	236	PS. 134	✓	✓	✓	✓
DYER-FREEMAN, J	" ORIENTATION	JUNE 19/90	237	PS. 135	✓	✓	✓	✓
HORNBY, J.T.	4433 W. 7TH VANC. B.C. V6R 1X1	"	238	PS. 136	✓	✓	✓	✓
CATON, R.	DEFICIENCIES - AIR QUALITY	"	239	PAN/EX. 8	✓	—	✓	✓
ROCK, CONNIE	NO ADDRESS	"	240	PS. 137	—	—	✓	✓
PAUL, JULIE	DPA MGMT. CONSULTING SUITE 402 475 HOWE VAN. B.C. V6C 2B3	"	241	PS. 138	✓	✓	✓	✓
HAWKES, KO	BOX 217 SOINTULA	"	242	PS. 139	✓	✓	✓	✓
BLAIR, D. MRS.	BOX 391, JOINTULA	"	243	PS. 140	✓	✓	✓	✓
VANDERHYDE, J.	GENERAL DELIVERY SOINTULA	"	244	PS. 141	✓	✓	✓	✓
MCMURDY, R.	BOX 214 SOINTULA	"	245	PS. 142	✓	✓	✓	✓
GRIFFITH, K.	BOX 212 SOINTULA	"	246	PS. 143	✓	✓	✓	✓
GLITZINE, ANITA	BOX 293 SOINTULA	"	247	PS. 144	✓	✓	✓	✓
GLITZINE, NICHOLAS	BOX 293 SOINTULA	"	248	PS. 145	✓	✓	✓	✓
WILKINS, S.P.	SIGMA ENGINEERING 800 - 1176 W GEORGIA VAN. V6E 4A2	"	249	PS. 146	✓	✓	✓	✓
WHITECAD, MARTY	ROTARY CLUB BOX 1890 P.R.	"	250	PS. 147	✓	✓	✓	✓
GRANT, BOB	UCANU	"	251	PS. 148	✓	✓	✓	✓
GYON, DAVID	BOX 26, SOINTULA	JUNE 22/90	252	PS. 149	✓	✓	✓	✓
THOMPSON, A.G.	T. BUCK SOZUK / 180 - 111 VICTORIA DRIVE VANCOUVER V5L 4C4	"	253	PS. 150	✓	✓	✓	✓
BETTS, JANET MS.	BOX 41, PORT MCNEILL	JUNE 24/90	254	PS. 151	✓	✓	✓	✓
BLAIR, D. MRS.	BOX 391, SOINTULA	"	255	PS. 152	✓	✓	✓	✓
DENHOFF, E.	MIN. OF NATIVE AFFAIRS	"	256	GVT. 24	✓	—	✓	✓
SAGERT, PETER	CIRRUS CONSULTANTS	"	257	PAN/EX. 9	✓	—	✓	✓
WOODWARD, P.J.	SHERWOOD	"	258	PRO. 20	✓	—	✓	✓

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ALFRED, P. CHIEF	NIMPKISH BAND Box 210 ALERT BAY	JUNE 19/90	259	PS·153	✓	✓	✓	✓
ROCK, CONNIE	BOX 344, SOINTULA	JUNE 26/90	260	PS·154	✓	✓	✓	✓
WEDDING, P.J.	SHERWOOD	JUNE 25/90	261	PRD·21	✓	—	✓	✓
PANEL	AGENDA UPDATE		262	PANEL·32	—	—	✓	✓
WEDDING, P.J.	SHERWOOD		263	PRD·22	✓	—	✓	✓
Sandborn	(C&NI questions to Sherwood)	June 28/90	264	PS. 155	✓	—	✓	✓
Sandborn	"	"	265	PS. 156	✓	—	✓	✓
Gubleman	"	"	266	PS. 157	✓	✓	✓	✓
DUVAL, WAYNE	ESL / COMMENTS	JUNE 29/90	267	PAN/EX·10	✓	—	✓	✓
CATON, ROBERT.B.	"	"	268	PAN/EX·11	✓	—	✓	✓
EMERSON	NI HEALTH UNIT	"	269	GOVT. 25	✓		✓	✓
SNOW	CHROMIUM REVIEW / DFE	"	270	PRD·23	✓		✓	✓
SNOW	ELDERS / DFE	"	271	PRD·24	✓		✓	✓
LANDON, D.	JUST PEOPLE	"	272	PS. 158	✓		✓	✓
NICHOL, JACK	UFAWU	"	273	PS. 159	✓		✓	✓
AUSTIN, B.	KHOYATAN MARINE LAB	JULY 2/90	274	PS. 160	✓		✓	✓
LEMMON, Wm. A.	FERRO PROCESS ASSESSMENT / DISCUSSION REPORT (1)	JULY 3/90	275	PAN/EX·12A PAN/EX·12	✓			✓
PANEL	OPERATIONAL PROCEDURES	"	276	PANEL·33	—		✓	✓
WILD, JAMES	COEFFITHER CHARTERS c/o QUARTERDECK MARINA 6685 MARPOLE CRES. RD.	"	277	PS. 161	✓		✓	✓
HILLMAN, STAN	REGIONAL DISTRICT OF MT. WADDINGTON	"	278	PS. 162	✓		✓	✓
WEDDING	BASD FOR POLLUTION CONTROL	"	279	PRD. 25	✓		✓	✓
WEDDING	TO SANDBORN	"	280	PRD. 26	✓		✓	✓
WEDDING	TO LEMMON	"	281	PRD 27	✓		B ✓	✓
GENERAL PUBLIC	FORM LETTERS / HEARING POSTPONEMENT	"	282	PS. 163	✓			✓
HODGKINSON, J	BRADFORD / KNEROON 1292 CLIVEDEN AVE. NEW WESTMINSTER V3M 6G4	"	283	PS. 164	—	tel.		✓
LEWIS, A.G.		"	284	PAN/EX·13	✓		Q/G/R	✓
HUDDLESTAN, A.	DISTRICT OF PORT HARDY	"	285	PS. 165	✓	✓		✓
ROBERTS, KIM		JULY 4/90	286	PS. 166	✓	✓		✓
WITZEL, BRUCE	BOX 359, PORT ALICE	"	287	PS. 167	✓	✓		✓
VOLKER, DARRELL	BOX 1631 PORT HARDY	"	288	PS. 168	✓	✓		✓
RANSOME, T.	BOX 352, SOINTULA	"	289	PS. 169	✓	✓		✓
LINFORD, S	BOX 135, SOINTULA	"	290	PS. 170	✓	✓		✓
SHAPPER, M		JULY 6/90	291	PAN/EX. 14	✓		Q/G/R	✓
Lemmon, Wm.		July 6/90	292	PAN/EX. 15	✓		Q/G/R	✓
B.C HYDRO	O.I.C. - POWER RATES	"	293	GOVT. 26	✓			✓
SNOW, R.	DEFICIENCY RESPONSE PROGRESS	JULY 3/90	294	PRD. 28	✓		G/Q/R	✓
PANEL	LETTER TO SNOW - HEARING POSTPONEMENT	JULY 5/90	295	PANEL·34	✓		G/Q/R	✓
THOMAS, DAVID	GEAKEM	JULY 4/90	296	PAN/EX·16	✓		Q/G/R	✓
PANEL	INFO BULLETIN #5 7 8	JULY 5/90	297	PANEL·35	✓			✓
BRIMBLECOMBE, J.K.		July 9/90	298	PAN/EX·17	✓		Q/G/R	✓
HATALLOY CORP	C1 + 6 PRODUCTION BACKGROUND INFO	"	299	BI·23	—	/		✓
General Public	Form letters	July 10/90	300	PS. 171	—	/		✓
PANEL	(duplicate)	July 6/90	301	PANEL·35	—	/		✓

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Snow, R.		July 10/86	302	Pro. 29	✓		Q/G/R	✓
Parton, K	Box 334, Sointula BC V0N-3E0	"	303	PS. 172	✓	✓		✓
Panel - Williams	(declined)	"	304	Panel. 36	✓		Q/G/R	✓
Coon, M	Min. of Agriculd. + Fisheries	"	305	Govt. 27	✓		G/R/Q	✓
Youds	letter to experts	July 11/86	306	Panel. 37	✓			✓
Youds	letter to editor	July 12	307	Panel. 38	—		G/R/Q	✓
GENERAL PUBLIC	FORM LETTERS (mailed in bulk)	"	308	PS. 173	✓			✓
COON, M.	AQUACULTURE/COMMERCIAL FISHERIES BRANCH	"	309	GOVT. 28	✓		Q/G/R	✓
DIEMER, HARRY	MUNICIPAL AFFAIRS, REC. + CULTURE	"	310	GOVT. 29	✓		Q/G/R	✓
Chapman, EVS	: .. :	JULY 13	311	Pan/Ex 18	-		Q/G/R	✓
GENERAL PUBLIC		"	312	PS. 174	-		R	✓
HUBBARD, L.T.	MINISTRY OF ENVIRONMENT	"	313	GVT. 30	✓		R	✓
Fruehan		"	314	Pro. 30	-		Q/G/R	✓
ANDERSON, B	CRUISE SHIP COMMITTEE CO-ORDINATOR Box 249 PH.	JULY 16	315	PS. 175	✓	✓	R	✓
GENERAL PUBLIC	FORM LETTER	"	316	PS. 176	-		R	✓
SNOW, K.			317	PRO. 31	-		Q/G/R	✓
General Public	form letters (mailed in bulk)	July 19	318	PS. 177	-		R	✓
BLAIR, M.D.	Box 391, SOINTULA	July 23	319	PS. 178	✓	✓	R	✓
BRIMACOMBE, J.K.		"	320	PANEX. 19	-		Q/G/R	✓
MACALLUM / ETC.	BACKGROUND INFO PROVIDED BY CURRUS	"	321	BI. 24	-		Q/G/R	✓
EMERSON, B.D.	MINISTRY OF HEALTH	JULY 24	322	GOVT. 31	-	—	Q/G/R	✓
GALE, STUART	MINISTRY OF TOURISM	"	323	GOVT. 32	-	/	Q/G/R	✓
PANEL	(Summary of town)	July 26	324	PANEL. 39	-	/	R	✓
United Fishermen and Allied Workers		"	325	PS. 179	-	/	R	✓
R.S. Placas	Min. of Regl + Ec Dev		326	Govt. 33	-	/	R	✓
General Public	7 additional form letters re July hearings 3"		327	PS. 180	-	/	R	✓
Cook, Lynn	Gen. Delivery, Quesnel V0N 2V0		328	PS. 181	✓	/	R	✓
E.P.A.	IRIS background info re chromium		329	BI. 25	-		R	✓
Austin	1968 letters to Woodsum		330	BI. 26	✓	/	R	✓
Klaven, B	Pt. Hardy Ec. Dev. Com.	Aug 16	331	PS. 182	✓	✓	R	✓
Dalton, R.	Box 499, Alert Bay V0N-1A0	"	332	PS. 183	✓	/	R	✓
Dodson, R	Western Diversification	"	333	BI. 27		/	R	✓
Woodsum, P.J.	Sherwood	Aug 27	334	Pro. 32		/	Q.G.R	✓
Rescan	EIS Addendum	"	335	Pro. 33		/	Q.G.R	✓
Swanson, V	Box 117 Sointula BC V0N-3E0	"	336	PS. 184	✓	/	R	✓
Consulate General of Japan	c/o Suite 900-1177 West Hastings, Vanc V6E-2K9	"	337	Govt. 34	N/A		R	✓
Youds	Info bulls 9 + 10	/	338	Panel 40	/	/	R	✓
Rescan	errata	Sept. 4	339	Pro. 34	/	/	R	✓
PANEL	letter to Woodsum	SEPT. 10	340	PANEL 41	/	/	R	✓
PANEL	LETTER TO GOVT. PARTICIPANTS / HOLLINGSHEAD	"	341	PANEL 42	/	/	R	✓
WOODSUM	RESPONSE TO PANEL'S SEPT. 10 LETTER	SEPT. 14	342	PRO. 35	/		Q/G/R	✓
CHROMIUM CENTRE	BACKGROUND INFO	"	343	BI. 28	/		R	✓
PITCHERS, R.	SHERWOOD / RESPONSE TO SHAFFER QUESTIONS	SEPT. 18	344	PRO. 36	/		R	✓

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PANEL	HEARINGS SCHEDULE		345	PANEL 43	-		Q/G/R	✓
JUST PEOPLE	C.K YOUDS/ORIGINAL TO SCHAFFER	SEPT. 18	346	PS. 185	✓	✓	/R	✓
CATON, R	EIS ADDENDUM REVIEW	SEPT. 19	347	PAN/EX. 20	-		Q/G/R	✓
YOUDS	LETTER TO GOVT. OFFICES		348	PANEL 44	-		R	✓
LEMMON, Wm. A.	TECHNICAL REPORT	"	349	PAN/EX 21	-		Q/G/R	✓
PANEL	LETTER TO JOHN MILLEN		350	PANEL 45	-		/R	✓
PANEL	LETTER TO SPROUT		351	PANEL 46	-		/R	✓
SHAFFER, M	TECHNICAL/SCCIO REPORT		352	PAN/EX. 22	-		Q/G/R	✓
Duval, W	final report	"	353	PAN/EX. 23	-		Q/G/R	✓
Roberts, K			354	PS. 186	-	✓	Q/G/R	✓
Rumbolt, M	reply to late Sherwood submission	"	355	PANEL 47	-		Q/G/R	✓
Thomas - SeaKem		"	356	PAN/EX. 24	-		Q/G/R	✓
Environment Canada -	technical submission	"	357	Govt. 35	-		Q/G/R	✓
Emerson, B.P.	LETTER RE: EIS ADDENDUM REPORT	"	358	Govt. 36	-		Q/G/R	✓
	MINISTRY OF ENVIRONMENT - TECH. SUB.	SEPT. 20	359	Govt. 37	-		Q/G/R	✓
CHAPMAN, P.	E.V.S. TECHNICAL REPORT	SEPT. 24	360	PAN/EX. 25			Q/G/R	✓
Lewis.		"	361	PAN/EX. 26			Q/G/R	✓
Brimacombe		"	362	PAN/EX. 27			Q/G/R	✓
Cirrus.		"	363	PAN/EX. 28			Q/G/R	✓
Brimacombe		Sept. 25/90	364	PAN/EX. 29			Q/G/R	✓
SNOW. R	TO SHAFFER	SEPT. 25/90	365	PRO. 37			R	✓
SNOW. R	TO CHAPMAN	SEPT. 25/90	366	PRO. 38		Chapman	R	✓
SNOW. R.	TO WARNECK	"	367	PRO. 39			R	✓
MILLEN, J.	HEARING PRESENTERS	SEPT. 21/90	368	GOVT. 38			R	✓
WEDDING, J.		SEPT 26/90	369	PRO. 40			Q/R/G	✓
SANDBERN, C	CHROMIUM DOCUMENT	SEPT. 25/90	370	PS. 187			~~R~~/R	✓
SNOW. R	TO KIM RORERTS	SEPT. 27/90	371	PRO. 41			Q/R	✓
SNOW. R.	US Court ruling re Chromium	Sept. 28/90	372	EI. 29			Q/R	✓
Chapman.		Oct. 1/90	366	PRO. 38 (R)				✓
Denbott	Min. of Native Affairs	Oct 2/90	373	Govt. 39				✓
Campoy.	Elders.	Oct. 3/90	374	Pro. 42				✓
Brimacombe.		Oct. 3/90	375	PAN/EX. 30	Exhibit #'s:		Commencement	
Williams.	Opening Remarks	Oct. 4/90	376	PANEL 48	E.1		of Hearings	
Higgins. R.	D.F.O	Oct 4/90	377	Govt. 39	E.2			✓
Wooding.	C.V.	Oct. 4/90	378	Pro 43	E.3			✓
Sherwood.	Opening Remarks	Oct. 4/90	379	Pro. 44	E.4			✓
Pitchers. R.	C.V.	Oct. 4/90	380	Pro. 45	E.5			✓
Fruehan. R	C.V.	"	381	Pro 46	E.6			✓
"	address	"	382	Pro 47	E.7			✓
Beale Spot M	C.V.	"	383	Pro 48	E.8			✓
Fullerton	C.V.	"	384	Pro 49	E.9			✓
Marsland	C.V.	"	385	Pro 50	E.10			✓
Rescan.	water treatment flows	"	386	Pro 51	E.11			✓

Name		Date	Seq.	File	Exhibit			Circulated
! Hartford, W	C.V.	Oct. 4/90	387	Pro. 52	E. 12			✓
Rescan	Treated Water Quality chart	"	388	Pro. 53	E. 13			✓
Stewart, P	C.V.	"	389	Pro. 54	E. 14			✓
Campney, L	C.V.	"	390	Pro. 55	E. 15			✓
Stewart, P.	notes.	"	391	Pro. 56	E. 16			✓
Mitchell.	C.V.	"	392	Pro. 57	E. 17			✓
Lemmon	permit conditions	"	393	Pan/Ex. 31	E. 19			✓
Frueham.		"	395	Pro. 58	E. 18			✓
Western Diversification - Heartwell		"	394	Gov't. 40				✓
EPA	page submitted by Sandborn.	Oct 5/90	396	BI. 30	E. 20			✓
Sherwood.	1969 letter.	"	397	BI. 31	E. 21.			✓
Lemmon.	C.V.	"	398	Pan/Ex. 32	E. 22			✓
Peters, E.	C.V.	Oct. 9/90	399	Pan/Ex. 33	E. 23			✓
Rescan.	revised tables 4-10 + 5-2	"	400	Pro. 59	E. 24			✓
"	PLANT EMISSIONS: CHROMIUM EST. / ENVIRON. LOAD	"	401	Pro. 60	E. 25			✓
"	RECEPTOR GRID PLOT: ISCST + RTDM	"	402	Pro. 61	E. 26			✓
"	QUATSE RIVER - TRACE ELEMENT LOADING	"	403	Pro. 62	E. 27			✓
MOE	Reynolds - Non Compliance	"	404	BI. 32	E. 28			✓
MOE	Pollution control objectives	"	405	Govt. 41	E. 29			✓
! MOE	Threshold limit values	"	406	Govt. 42	E. 30			✓
Flather	C.V.	Oct 9	407	Pro. 63	E. 31			✓
KESSLER	C.V.	"	408	Pro. 64	E. 32			✓
WERRING	C.V.	"	409	Pan. 65	E. 33.			✓
PUBLIC QUESTIONS		"	410	PS. 189				✓
EPA	"Top Down" BACT	Oct. 6/90	411	BI. 33	E. 34			✓
! South Coast Air Quality Mgmt. Dist.		"	412	BI 34	E. 35			✓
EPA	Guideline On Air Quality Models	"	413	BI. 35	E. 36			✓
U.S. Dept of Ecology		"	414	BI. 36	E. 37			✓
Lemmon, W.	def'n of BACT	"	415	Pan/Ex. 34				✓
Swyst, P.	C.V.	"	416	Pan/Ex. 35	E. 38			✓
HARTUNG, W	SWEDISH IRON + STEEL INDUSTRY / INCRIMIL	"	417	Pro. 66	E. 39			✓
SPITTERS, M	LETTER TO SHOW	"	418	Pan/Ex. 36				✓
CATON, B	C.V.	OCT. 11/90	419	Pan/Ex. 37	E. 40			✓
CATON, B	CHROMIUM OVERHEAD DIAGRAM	"	420	Pan/Ex. 38	E. 41			✓
PITTERS, B.	CHROMIUM STANDARDS / C[illegible]	"	421	Pro. 67	E. 42			✓
! BIDSTRUP, DR.	C.V.	"	422	Pro. 68	E. 43			✓
BIDSTRUP PRESENTATION	OVERHEADS	"	423	Pro. 69	E. 44			✓
NEWARK "STAR LEDGER"	ARTICLE RE CANCER / CHROMIUM	"	424	BI. 37				✓
	EPA EXTRACT	"	425	BI. 38	E. 45			✓
	CAP DISCUSSION PAPER	"	426	BI. 39	E. 46			✓
SANDBORN	NEWARK - CHROMIUM / CANCER	"	427	BI. 40	E. 47			✓
Schroeder, et al. SANDBORN	ENVIRONMENTAL HEALTH CRITERIA 5	"	428	BI. 41	E. 48			✓
			429	BI. 42	E. 49			✓

NAME		DATE	SEQ.	FILE	EXHIBIT			Circulated
Sandberg, D.	public hearing presentation	Oct 11/90	430	BI 43	50			✓
Min. of Env. + Parks		"	431	BI 44	E.51			✓
Nanaga.		OCT 12/90	432	Govt. 43	E. 52			✓
Holdaway.		"	433	BI. 45	E.53.			✓
James, et al.		"	434	BI. 46	E.54.			✓
Nanaga	credentials	"	435	Govt 44	E.55			✓
Moore.		"	436	Pro. 70	E.56			✓
Lake Bruk.		"	437	Pro. 71	E.57.			✓
Fruehan.		"	438	BI. 47	E.58.			✓
Dist. of Port Hardy		"	439	BI. 48	E.59.			✓
" "	(full report # of E.59)	"	439A	BI. 48A	E.59A			✓
Panel		"	440	Panel 49	E.60			✓
Birch. G.	C.V.	"	441	Pro. 72	E.61			✓
Griesbaum, P.	CV.	"	442	Pro. 73	E.62			✓
DUNCAN, W.F.A.	C.V.	"	443	Pro. 74	E.63.			✓
BIRCH, G	VEGETATION OVERHEAD!	"	444	Pro. 75	E.64			✓
Griesman. P	overhead slides.	"	445	Pro. 76	E.65			✓
Werring,	" "	"	446	Pro. 77	E.66			✓
ZIKA, SELTZMAN, ETAL	HYDROGEN PEROXIDE CONCENT. IN THE PEACE UTILIZING	"	447	BI. 49	E.67			✓
US Public Health Service	Chromium.	"	448	BI. 50	E.68.			✓
DUNCAN,	OVERHEADS/MONITORING PROG. OBJECTIVES	"	449	Pro. 78	E.69			✓
LARSNE, N	BOX 1620, PORT HARDY / PRESENTATION	OCT 12	450	PS. 190				✓
MIEPS	SURVEY	OCT 13	451	PS. 191				✓
Mitchell, R		Oct 13	452	PS 192				✓
United Fishermen and Allied Workers Union.		"	453	PS 193				✓
Mackay. I.		"	454	PS 194				✓
Jink. S.		"	455	PS. 195				✓
Maloney, B.	statement form	Oct. 15/90	456	PS. 196.				✓
Liepins. N	statement form	"	457	PS. 197				✓
Hancock. L.	letter	"	458	PS 198		Reply		✓
Robertson. R	letter	"	459	PS 199		Reply		✓
HUDDLESTAN, A	letter	"	460	PS. 200	E.70.			✓
Rankin - Sargent	cover letter + BACT evaluation	"	461	Panel 50	E. 71.			✓
Caton. R	reference info emission limit tables	"	462	Panel 39	E. 72.			✓
CANADA	Clean Air Act	"	463	Govt. 45	E. 73.			✓
RESCAN.	overheads. Chromium	"	464	Pro. 79	E. 74			✓
CANTEST		"	465	BI. 50	E.75			✓
New Jersey DEP		"	466	BI. 51	E.76.			✓
FISH SERVICE, U.S.	CHROMIUM HAZARDS TO FISH	"	467	BI. 52	E 77			✓
NORTH COAST WATER CONTROL BOARD	/ WATER QUALITY CONTROL PLAN	"	468	BI. 53	E 78			✓
ENRIGHT, J. T.	POWER PLANTS AND PLANKTON	"	469	BI. 54	E. 79			✓
EPA	ESTUARINE HABITAT RESTORATION MONITORING	"	470	BI. 55	E. 80			✓
SCIENCE, VOL 249	ZEBRA MUSSEL INVASION	"	471	BI. 56	E. 81			✓

	NAME		DATE	SEQ	FILE	EXHIBIT			Circ
	PRITCHARD, H	STATEMENT ON BUILDING LOCATIONS	OCT. 15/90	472	PS·201				✓
	CHAPMAN, P. Dr	OVERHEADS + PRESENTATION	Oct 16/90	473	PN/EX·40	E·82			✓
	CHAPMAN, Dr. P.	CV	"	474	PN/EX·41	E·83			✓
	Lewis, A.	overhead slides.	"	475	PN/EX·42	E. 84			✓
	EPA	AIR EMISSIONS / STACK HEIGHTS	"	476	BI·57	E·85			✓
	DUVAL	CV	"	477	PN/EX·43	E·86			✓
	DUVAL	PRESENTATION	"	478	PN/EX·44	E·87			✓
	ENVIRON CANADA	PRESENTATION STATEMENT	"	479	GOVT·46	E·88			✓
	FISHERIES + OCEANS	FISH HABITAT MGMT. POLICY	"	480	GOVT·47	E·89			✓
	"	Langer letter.	"	481	GOVT·48	E.90			✓
	Environment Canada	reference docs	"	482	BI. 58	E.91			✓
	Ransome	statements	"	483	PS 202				✓
	de Walley.	"	"	484	PS·203				✓
	Russell, M	"	"	485	PS.204				✓
	Whyte, et al.	Heavy Metals in "Kelp" study.	"	486	BI. 59	E.92			✓
	Bussey, B. J.		Oct 17 /90	487	PRO. 80	E.93			✓
	PLECAS, R.S.	Ministry of Regional + Economic Dev.	"	488	GOVT. 49				✓
	ROSBOROUGH, R	BOX 2038 PORT HARDY NORTH FJORD FISH FARMS	"	489	PS. 205	E 94			✓
	HORNAL, R	C.V.	"	490	PRO. 81	E. 95			✓
	BURGESS, K	NEWSPAPER ARTICLE	"	491	PS. 206				✓
	Sherwood,	OVERHEAD SLIDES	"	492	PRO. 82	E·96			✓
	SANDWELL/INGLIS	DEEP SEA PORT FACILITY	"	493	BI·60	E·97			✓
	Hartford, W	Three Major Classifications of Chromium	"	494	PRO. 83	E. 98			✓
	F. Hornal	overhead slides	Oct 18	495	PRO. 84	E.99			✓
	Ministry of Environment.		"	496	Govt. 50	E·100			✓
	SCHAFER, M	PRESENTATION	"	497	PN/EX·45	E·101			✓
	B.C. MIN. OF ENERGY MINES & PETROL. RESOURCES	METALLOGY TASK FORCE SUMMARY	"	498	BI·61	E.102			✓
	HODDING	LETTER RE SOCIO-ECONOMIC POLICY	"	499	PRO·85	E. 103			✓
	WEDDING	LETTER RE: BACT	"	500	PRO·86	E. 104			✓
	SHERWOOD	ESTIMATE OF HEAT BALANCE	"	501	PRO·87	E 105			✓
	VOLD, DORIS	GENERAL DELIVERY, QUATSINO VON 2VO	"	502	PS. 207				✓
	RICHARDSON, M.	GCN. DEL. QUATSINO	"	503	PS 208				✓
	Nahlegan, J	response to Hartford		504	Govt. 51	E. 106			✓
	Sherwood.	newspaper insert.		505	PRO. 88	E. 107			✓
	F. Min of Tourism			506	Govt. 52				✓
	E Min of Native Affairs			507	GOVT. 53				✓
	E PATH, C.H.	HERITAGE CONCERNS		508	PS. 209	108			✓
	N KWAKIUTL	MAP - LAND CLAIM - KWAKIUTL		509	PS 210	109			✓
	KWAKIUTL	KWAKIUTL DECLARATION + CLAIM / SIGNED		510	PS. 211	110 + 110A			✓
	"	LETTER OF LAND CLAIM TO FLDS.		511	PS. 212	111			✓
	"	KWAKIUTL PRESENTATION		512	PS. 213	112			✓
	"	RESOURCE MAPS		513	PS. 214	113			✓
	NIET, JHG.	CV		514	PS. 215	114			✓

NAME		DATE	SEQ	FILE	EXHIBIT			Circulated
ROBINSON, Dr. S	KWAKIUTL LAND CLAIMS	OCT. 18/90	515	PS. 620	115			✓
NIET, J.H.G.	TRI-BAND COUNCIL - ECONOMIC DEVELOPMENT	OCT 18/90	516	PS 218	116			✓
BC Hydro		"	517	Govt. 54	117			✓
YOUDS.		"	518	Panel 51	✓			✓
BC Min. of Environment		"	519	Govt 55	118			✓
Cotfurther Chuntera		"	520	PS. 28				✓
McLennan, S.	District of Port Hardy	"	521	PS 219				✓
Dalen, R	letter to M. Moore	Oct. 19	522	Govt. 56				✓
N. Aitken		Oct. 19	523	PS. 220				✓
Woolridge, R.	Box 361. Sointula BC VON 3E0	"	524	PS. 221				✓
Hawkes, Ku		"	525	PS. 222				✓
Youds	reply to Plecas	Oct. 18	488	Gov. 49	(R)			✓
Seigbold, H.	Box 1257, Port Hardy BC	Oct 22	526	PS. 223				✓
EPA	Chromium; Test Method	Oct. 22	527	EI. 63				✓
Morrison, D.	Min. of Environ.	"	528	Govt. 57				✓
Botel, R+G	Box 1664, P.H. VON 2P0	Oct 22/90	529	PS. 224				✓
Wilson, R. (Mr + Mrs)	RR#1, Genoa Bay Rd, Duncan	"	530	PS. 225				✓
Goyette, D.	Environment Canada	"	531	Govt. 58				✓
Brauer, K.	post hearings concerns	Oct 24/90	532	PS. 225				✓
Oldham, T.	reply to Snow (Sept 25)	Oct. 26/90	367	Pro. 39	(R)			✓
Edwards, K	letter; Box 377 Sointula VON 3E0	"	533	PS 226				✓
Kenny, R.	Archaeology Branch.	Oct. 29/90	534	Govt. 58	Error!			✓
Lankanen, A.	form letter from June	"	536	PS. 227	There is no 536			✓
Pitchers, R.	Org. chart + hiring info.	"	537	Pro. 84	Sally			✓
Rowell, J	Village of Alert Bay	Oct. 30/90	538	PS. 228				✓
Snow, R.	re hearings.	"	539	Pro. 90				✓
Sandborn, C	letter to Snow (Oct. 30)	"	540	PS. 229	-			✓
Truscott, J.	Ministry of Agriculture	"	541	Govt. 59				✓
Youds, J K	Info Bull. #11	NOV. 1/90	542	Panel. 52				✓
Geddes, J+B	letter. Box 89, Dated Flnl, Ca, VIA 95714	NOV. 6/90	543	PS. 230				✓
Rankin, M.	reply to Snow	Nov. 6/90	534	Pro. 40	(R)			✓
Sherwood	7th Supplemental	Nov. 4/90	544	Pro. 91				✓
Johnson, E.	Box 233, Sointula BC VON 3E0	Nov. 14/90	545	PS. 231				✓
Sandborn	input from Nanaimo	"	546	PS 232				✓
Snow, R.	compiled info re Chromium standards	Nov. 15/90	547	Pro. 42				✓
Nichol, C.	chromium	"	548	PS 233				✓
Field, R.	hydro rates	"	549	PS. 234	+ Tracy, H. = 549-A PS. 234-A.			✓
Sherwood	Sixth Supplemental	"	550	Pro. 43				✓
Sherwood	Energy between - add to 7th supplement	"	551	Pro. 44	Nov 15 deadline			✓
YOUDS	memo re. file corrections	Nov. 20	552	Panel 53				
Sandborn, C	letter to Snow	Nov. 20	553	PS. 235				
Sandborn, C.	submission from Lennon attached	"	554	PS. 236				
Groff, N.	letter	"	555	PS. 237				

NAME		DATE	SEQ	FILE	EXHIBIT	
Sandborn, C	submission from Caton attached	Nov. 22/90	556	PS.238		
Wocks, L.	letter (no address)	"	557	PS.239		
Sagert, P	article re Environ. Risks.	Nov 23/90	558	Book 46		
Snow	final argument	Nov. 27/90	559	Pro.95		
Sandborn	" "	"	560	PS.240		
Hancock	letter re final argument	"	561	PS.241		
Harris, R.	" " " "	"	562	PS.242		
Brauer, K.	" " " "	"	563	PS.243		
ROBERTS, K.		"	564	PS.244		
MOORE, P		"	565	PS.245		
SAGERT, P.	LETTER TO PARTICIPANTS	NOV. 29/90	566	PAN/EX47		
SANDBORN, C	PERMIT CONDITIONS	NOV. 28/90	567	PS.246		
SAGERT, P.	Rfc from E.P.A.	NOV. 29/90	568	PAN/EX48		
SHORWOOD	REVIEW OF CARCINOGENIC PK CONTAMINANTS	DEC. 1/90	569	PRO.96	E119	
SNOW	CHROMIUM REFERENCE LEVEL	"	570	PRO.97	E120	(appears to be information * Same as 568 Pan/E
SNOW	LINDBERG + HEDENSTIERNA STUDY	"	571	PRO.98	E121	
SANDBORN, C	FINAL ARGUMENT HEARING COPY	"	572	PS.245	E122	
RANKIN, M.	FINAL SUBMISSION	"	573	PANEL.54	E123	
Brauer, K.	" " of UFAWU.	Dec. 5/90	574	PS.246		
Roberts, K.	" " of Kwakiutl	Dec. 7/90	575	PS.247		
Snow, R.	Reply to questions	"	576	Pro.99		
Snow R.	Reply to final argument	"	577	Pro.100		
Denhoff, E.	response to hearings questions	Dec. 11/90	578	Govt.60		
Youds.	letter to MoE - Veigt	NOV. 28/90	579	Pan. 55		

APPENDIX E

HEARINGS SCHEDULE

Port Hardy Ferrochromium Review Panel

OCTOBER HEARINGS SCHEDULE

Date, Day	Morning Session (8:30 start)	Afternoon Session (1:15 start)	Evening Session (7pm -)
Oct. 4th, Thursday	Technical Overview; process technology; project feasibility; pollution control technology	Technical	Technical (as needed)
Oct. 5th, Friday	Technical (continuation of Oct. 4th agenda)	Technical	
Oct. 9th, Tuesday	Technical Air emissions	Technical	Community Port Hardy
Oct. 10th, Wednesday	Technical Air emissions, cont'd.	Technical	Community Pt.McNeill Lions Hall
Oct. 11th, Thursday	Technical Public health aspects of air emissions.	Technical	
Oct. 12th, Friday	Technical Marine & terrestrial issues.	Technical	Community* Ft.Rupert\ Beaver Harb. Lions Hall
Oct. 13th, Saturday		Community* Sointula Old Firehall **(2 p.m. start)	Community* Sointula Old Firehall
Oct. 14th, Sunday		Community * Alert Bay Community Hall **(1:30 start)	
Oct. 15th, Monday	Technical Marine & terrestrial issues, cont'd.	Technical	
Oct. 16th, Tuesday	Technical 1. Marine & terrestrial issues 2. Archaeological issues	Technical	
Oct. 17th, Wednesday	Technical Socio-economic issues.	Technical	Community Port Hardy
Oct. 18th, Thursday	Technical Socio-economic issues, cont'd.	Technical	Community Port Hardy
Oct. 19th, Friday	Technical and/or Community (Panel's option - Port Hardy)		

NOTE All "Technical Sessions" will be held in Port Hardy. All technical and community sessions in Port Hardy will be held at the North Island Hall, "old liquor store". The identified subjects are approximations only.

* Community sessions noted with an asterisk (*) may be adjusted if it is learned that one or other of them directly conflicts with a specific, short term fishing

APPENDIX F

LIST OF EXHIBITS

LIST OF EXHIBITS TABLED AT HEARINGS

All exhibits have been assigned file numbers consistent with the filing system established for this review process. During the technical hearings, exhibits were distributed to the Panel, Sherwood representatives, and registered participants. Please use this list to organize your files.

Many exhibits are copies of previously published reports and other documents already in the public realm, or are the resumes of consultants testifying at the hearings. Such exhibits will not be re-copied by this office for public distribution, but they are listed below. Where appropriate, abstracts or cover pages have been copied in order to assist with identification, and these are noted on the following list by "Ab".

Exhibits which represent original submissions or which are not normally in the public domain have been photocopied for public distribution. These are identified by an asterisk.

Take note that the following list includes EXHIBITS ONLY. Exhibits are those files that were introduced as "evidence" during the technical hearings. In addition, other files have been added to our records since the hearings commenced. Please refer to your copy of the recent "File Register" pages for a complete listing of all files (including exhibits).

	EXHIBIT NO.	FILE NO.	DESCRIPTION
*	1	376-Panel.48	Chairman's opening remarks
*	2	377-Govt.39	DFO submission
	3	378-Pro.43	Wooding: curriculum vitae
*	4	379-Pro.44	Sherwood: Opening Address
	5	380-Pro.45	Pitchers: curriculum vitae
	6	381-Pro.46	Fruehan: curriculum vitae
*	7	382-Pro.47	Fruehan's address to Panel
	8	383-Pro.48	de Spot: resume
	9	384-Pro.49	Pelletier: resume
	10	385-Pro.50	Marsland: resume

*	11	386-Pro.51	Rescan: Water Treatment Flowsheet A
	12	387-Pro.52	Hartford: resume
*	13	388-Pro.53	Rescan: Treated Water Quality
	14	389-Pro.54	Stewart: resume
	15	390-Pro.55	Campoy: resume
*	16	391-Pro.56	Stewart: presentation notes
	17	392-Pro.57	Mitchell: cirriculum vitae
*	18	393-Pro.58	Fruehan: preliminary sulfur balance
*	19	394-Pan/Ex.31	Lemmon: Suggested Permit Conditions
	20	396-BI.30	p. 11812 Fed. Register, Vol.55, No.61
*	21	397.BI.31	Sherwood: 1989 letter to CRD
	22	398-Pan/Ex.32	Lemmon: Professional profile
	23	399-Pan/Ex.33	Peters: resume
*	24	400-Pro.59	Rescan: revised tables 4-10 & 5-2
*	25	401-Pro.60	Rescan: Plant emissions; chromium
*	26	402-Pro.61	Rescan: overhead slides re. air dispersion
*	27	403-Pro.62	Rescan: trace element loading
	28	404-BI.32	Ministry of Environment: non-compliance/pollution list
	29	405-Govt.41	Pollution Control Objectives
*	30	406-Govt.42	extract from Threshold Limit Values
	31	407-Pro.63	Flather: resume
	32	408-Pro.64	Kessler: resume
	33	409-Pro.65	Werring: resume
Ab	34	411-BI.33	EPA: BACT guidance document

	35	412-BI.34	South Coast Air Quality Management District; BACT Guideline.(extract)
	36	413-BI.35	EPA: Guideline on Air Quality Models.
	37	414-BI.36	Washington Dept. of Ecology
	38	416-Pan/Ex.35	Sagert: resume
*	39	417-Pro.66	Hartung: presentation notes.
	40	419-Pan/Ex.37	Caton: resume
*	41	420-Pan/Ex.38	Caton: presentation notes
Ab	42	421-Pro.67	Pitchers: draft document from South Carolina Department of Health
	43	422-Pro.68	Bidstrup: resume
*	44	423-Pro.69	Bidstrup: presentation notes.
	45	425-BI.38	EPA: extract from "Noncarcinogenic Effects of Chromium"
Ab	46	426-BI.39	Ontario: extract from discussion paper
*	47	427-BI.40	Datacenter: chromium wastes
*	48	428-BI.41	World Health Org.: Chromium
Ab	49	429-BI.42	Schoeder: "Potential Transformations of Chromium in Natural Waters"
	50	430-BI.43	Sandberg: 1988 presentation re. pollution monitoring in B.C.
	51	431-BI.44	Min. of Environment: annual report
*	52	432-Govt.43	Nriagu: presentation notes.
*	53	433-BI.45	Holdway: extract from "The Toxicity of Chromium to Fish"
	54	434-BI.46	Janus: appendix to "Integrated Crtieria Document Chromium Effects."
	55	435-Govt.44	Nriagu: resume

*	56	436-Pro.70	Oct.11/90 letter from Mr. Moon to Mr. Snow.
Ab	57	437-Pro.71	Hartung: permit conditions for Swedish fibre plant (in Swedish).
Ab	58	438-BI.47	Fruehan: "Activities of Na2O in CaO..."
Ab	59	439-BI.48	Port Hardy: draft water treatment study
*	60	440-Panel.49	Oct. 12/90 request to Sherwood for additional information.
	61	441-Pro.72	Birch: resume
	62	442-Pro.73	Greisman: resume
	63	443-Pro.74	Duncan: resume
*	64	444-Pro.75	Birch: presentation notes.
*	65	445-Pro.76	Greisman: presentation notes.
*	66	446-Pro.77	Werring: presentation notes.
Ab	67	447-BI.49	Zika: "Hydrogen Peroxide Concentrations..."
*	68	448-BI.50	Syracuse Research Corp: "Tox. Profile of Chromium"
*	69	449-Pro.78	Duncan: presentation notes.
*	70	460-PS.200	Huddlestan: Oct.15/90 letter to Williams.
*	71	461-Panel.50	Rankin: Oct.15/90 letter to Sherwood re. attached submission from P. Sagert.
*	72	462-Pan/Ex.39	Caton: Oct.12/90 submission to Panel re. emission limit tables.
Ab	73	463-Govt.45	Canada: Ambiant Air Quality Objectives
*	74	464-Pro.79	Rescan: annual total chromium and Cr(VI) loadings.

	75	465-BI.50	Cantest: 1989 report on Port Hardy Water Quality
*	76	466-BI.51	New Jersey Department of Environmental Protection: re. chromium in soil, risk assessment.
*	77	467-BI.52	U.S. Fish & Wildlife: Chromium Hazards to Fish (extract only)
	78	468-BI.53	North Coast Regional Water Quality Control Board (Calif.)
Ab	79	469-BI.54	Enright: "Power Plants and Plankton"
Ab	80	470-BI.55	EPA: "Estuarine Wetland Restoration Monitoring Protocol"
Ab	81	471-BI.56	Culliton (Science, Vo.249): " Zebra Mussel Invasion.
*	82	473-Pan/Ex.40	Chapman: presentation notes
	83	474-Pan/Ex.41	Chapman: cirriculum vitae
*	84	475-Pan/Ex.42	Lewis: presentation notes
	85	476-BI.57	EPA: Revised Stack Height Regulation
	86	477-Pan/Ex.43	Duval: resume
*	87	478-Pan/Ex.44	Duval: critique of Sherwood EIS
*	88	479-Govt.46	Environment Canada: position statement
	89	480-Govt.47	DFO: "Policy for the Management of Fish Habitat"
	90	481-Govt.48	Canada: "Inconsistent Application of the Fisheries Act."
*	91	482-BI.58	Environment Canada: exerpts from miscellaneous reference documents.
Ab	92	486-BI.59	DFO: "Assessment of Heavy Metals in "Kelp"..."
	93	487-Pro.80	Bussey: resume

*	94	489-PS.205	Rosborough: statement re. fish farm.
	95	490-Pro.81	Hornal: resume
*	96	492-Pro.82	Sherwood: profit distribution
	97	493-BI.60	Transport Canada: Port Hardy Sea Port Study (extracts only)
*	98	494-Pro.83	Hartford: "Three Major Classifications of Chromium (III) Compounds"
*	99	495-Pro.84	Hornal: presentation notes
*	100	496-Govt.50	MoE: response to Mr. Sandborn's question.
*	101	497-Pan/Ex.45	Shaffer: estimation of Hydro-Sherwood subsidy.
	102	498-BI.61	South Carolina Department of Health: Macalloy Task Force report (1987).
*	103	499-Pro.85	Sherwood: Oct.18/90 letter to Williams.
*	104	500-Pro.86	Sherwood: Oct.18/90 letter to Williams re. BACT
*	105	501-Pro.87	Sherwood: presentation notes re. heat balance.
*	106	504-Govt.51	Nriagu: response to Hartford.
	107	505-Pro.88	Sherwood: newspaper insert (N.I.G. October 3/90.
*	108	508-PS.209	Ham: archaeological and historical interests of Kwakiutl.
*	109	509-PS.210	Map of Kwakiutl Comp. Claim
*	110	510-PS.211	Kwakiutl Declaration and Claim (1984)
	111	511-PS.212	Min. of Native Affairs: letter accepting the filing of the Kwakiutl land claim.

*	112	512-PS.213	Kwakiutl presentation
*	113	513-PS.214	Kwakiutl presentation (maps)
	114	514-PS.215	Niet: resume
Ab	115	515-BI.62	Robinson: Report on the Comprehensive Land Claims of the Southern Kwakiutl Indians.
*	116	516-PS.217	Tri-Band Council Economic Development
*	117	517-Govt.54	B.C. Hydro: response to questions.
*	118	519-Govt.55	MoE, Oldham: response to question from Sandborn.

* * *

APPENDIX G:

CHROMIUM TOXICITY: BACKGROUND DISCUSSION

Chromium exists in two principal chemical forms or oxidation states. These are known as Chromium III and Chromium VI. The Chromium VI state corresponds to the classical hexavelant chromium (ie. Cr^{6+}) and the Chromium III state is then also often expressed as Cr^{3+}. The latter trivalent state is the stable form (thermodynamically) in the presence of reducing agents and in particular in the organic matter found in estuarine and terrestrial ecosystems and inside human beings, where its presence is both natural and, in small amounts, essential. Chemically, strong oxidation conditions such as hydrogen peroxide (as explained by Dr. Nriagu) or air, sodium oxide and high temperature, as might exist in a smelter, are needed to convert Chromium III to Chromium VI.

Once Chromium VI is formed, chromium also becomes in turn a strong oxidizing agent and "electrophilic" species. This may be familiar to us as potassium dichromate ($K_2Cr_2O_7$), the orange solid in old style "breathalyser" instruments which rapidly turned into green Chromium III compounds when it oxidized alcohol in human breath. The same oxidizing potential is thought by some to be the basis for the mutagenic and ultimately carcinogenic effects of Chromium VI. Based on both human epidemiology and animal studies, Chromium VI has been established as a human carcinogen (principally lung carcinoma) and a toxic hazard (respiratory effects) by the United States Environmental Protection Agency (US Public Health Service: Toxicological Profile for Chromium; file 448-BI.50).

Controversy exists over whether ingestion or inhalation of chromium III in some chemical forms may present a toxic hazard to human beings, including cancer. However, at low levels Chromium III is considered to be an ... "essential nutrient that helps to maintain normal metabolism of glucose, cholesterol and fat in humans. Daily ingestion of 50-200 micrograms ... (equivalent of 0.0007 - 0.003 milligrams of Chromium III per kilogram) is considered to be adequate for human nutrition" (U.S. Public Health Service). Notably, Chromium III (as the nitrate) is a constituent of some multi-vitamin preparations. Caution on extrapolation of such data to all species is immediately to be recognized. Evidence provided to the Panel explicitly has cited Chromium III, at least in water soluble forms, as being toxic to marine and aquatic organisms at relatively low levels. (Refer to Section 3.4).

In recognition of the established health risks of Chromium VI, the United States EPA has recently moved to release a "Reference Concentration for Chronic Inhalation Exposure" (RfC) for chromium. In consideration of the failure of current analytical procedures to accurately quantify CrVI in the presence of much larger amounts

of Chromium III, the United States EPA exposure is regulated at total chromium (i.e. CrIII and CrVI combined). A value for the yearly exposure has been set at 0.002 ug/Nm³.

The RfC is established in order to provide a daily dose for exposed persons that is without appreciable risk of deleterious effects during a lifetime. The RfC is an air concentration that estimates a daily exposure that is likely to be without observable general health effects over a lifetime for the human population including sensitive sub-groups. It is not specifically designed for other toxic effects such as carcinogenicity where such a threshold may not exist. However the RfC will correspond to a certain level of cancer risk if the toxic hazard also has that capability, as is the case with Chromium VI.

As an illustration of the foregoing, the 0.002 ug/Nm³ value for chromium is based on human occupational exposure (chrome plating plants) that establishes a Lowest Observable Adverse Effects Level (LOAEL) of 0.002 mg/m³. The adverse effects are nasal symptoms, specifically ulceration of the nasal mucosa. Such exposure for the 5 day 8 hour work week corresponds to 0.000714 mg/m³ for continuous lifetime exposure. When uncertainty factors (UF) are added for variations in human susceptibility, and to achieve a "No Observable Adverse Effect Level' (NOAEL), the value of 0.002 ug/Nm³ for total chromium is achieved.

The value is significantly different than that required to achieve the "one in a million" risk of carcinogenesis for Chromium VI, estimated by the EPA on the experience of chromate workers (Mancuso 1975, quoted in EPA/6008-83-014F Environmental Health Assessment Document for Chromium). That value is given as 0.00008 ug/m³, a factor of 25 lower. Clearly, if the Chromium VI content of the total chromium concentration is one twenty-fifth or less, then the 0.002 ug/m³ value also provides the one in a million risk level. It is important to note that the value for Chromium VI ambient air concentration suggested as the "EPA conservative estimate" (in Sherwood's "Seventh Supplemental Submission; (file 544-Pro.91, p.4) represents such a one in a million risk, and has been advocated as the Sherwood proposed standard (0.085×10^{-3}) (Table 5-2C, file 544).

In the context that has been developed in this background section, the central question that remains to be addressed is the appropriate ambient concentration levels for total chromium that should be established for the Sherwood process. Such regulated levels will depend on estimation of CrVI in the particulate air emissions, and the relationship of the 0.002 ug/m³ value to existing total chromium ambient air standards in British Columbia and other jurisdictions. A further factor will be the potential for change in the CrVI level in emitted particulates (by atmospheric oxidation) prior to contact with humans. Finally it must also be remembered that any total chromium value also needs to be at a

NOAEL (no observed adverse effect level) for terrestrial and marine life forms. Again, this must take into consideration the potential for oxidation of CrIII to CrVI by agents such as hydrogen peroxide and manganese dioxide.

* * *

APPENDIX H

EMISSION LEVELS FOR AIRBORNE CONTAMINANTS

In spite of the uncertainties in the applicability of the B.C. Ministry of Environment's 1979 emission values, the Panel received indications that NOx, SOx and particulate values were comparable to current BACT levels for these contaminants. First, the Panel was aware that the recommendations of Mr. W. Lemmon (consultant to the intervenors) were based on an exhaustive review of BACT technology for the integrated iron and steel industry, which had been recently (at the time of Mr. Lemmon's testimony) completed on behalf of the Ministry of Environment.

Next, published values for emissions were obtained by the Panel. For example, the 1989 (former) West German standards (TA Luft Regulations)* are: NOx = 200 mg/Nm^3; SOx = 100-200 mg/Nm^3; Particulate = 50 mg/m^3. Again, it is noted that these are <u>maximum</u> values and that they are very close to the proposed BACT values in the present instance.

As well, the <u>Compilation of Air Pollutant Emission Factors, Volume 1: Stationary point and Area Sources</u> (United States EPA, September 1985) provides some indication of <u>traditional</u> practice in the ferrochromium industry (high carbon). For example, for an open furnace, uncontrolled SO_2 has an emission factor of 5.4 lb/ton or 2.7 kg/tonne. At the proposed Sherwood production rate of 4 tonnes/hour (file 544-Pro.91: 25,000 tonnes per annum with 6000 hours of production) this would correspond to 21.6 kg. per hour of SO_2. The proposed mass rate for Sherwood is 1.07 kg/hour, with a permit level of 4 kg/hour. Again, it is emphasized that the latter values are based on low sulphur coal and favourable partition into the slag phase, not on any desulphurization or other control procedures. From a BACT point of view then, the Sherwood procedure is also an <u>uncontrolled</u> SO_2 emission <u>source</u>.

From the same U.S. EPA emission factors, particulate for ferrochromium (high carbon) is given as 1.2 kg/tonne controlled by ESP (electrostatic precipitation). The Sherwood proposal is 0.4 kg/hour or 0.1 kg/tonne (based on an anticipated normal operating

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* T.A. Luft. "First General Administrative Regulation Pertaining to the Federal Emissions Control Law (BIm SchG) March 1974. (BGBI. I, p.721).

"Technical Instructions on Air Quality Control (TA Luft) Fefruary Feb. 1986 (GMBI p.95, 202) Federal Republic of Germany.

level of 0.255 kg. per hour). The proponent has provided much information from the MacAlloy Corporation (Charleston, South Carolina), particularly in regard to emissions of total chromium and Chromium VI (see Section 3.2 of this report). The permit level at MacAlloy is 13.62 kg/hour (30 pounds/hour), in reference to a nominal production of 250,000 tons (file 321-BI.24). The total emissions in 1989 were 81,611 kg. of particulate, a value of only 0.326 kg/tonne if their nominal production (of 250,000 tons) was reached.

It is noted that some 19,522 kg. of the particulate was ascribed to fugitive emission, including tapping, pouring and material escaping from open furnaces. The fugitive emissions from tapping and pouring, which are often 60-70% captured by hooding, need to be carefully monitored since they directly affect the exposure of the workers in the plant to chromium-containing particles. Sherwood has not specified such fugitive emissions in terms of total kg/hour.

Based on an operating year of 8000 hours, the particulate emission level at MacAlloy was greater than 10 kg. per hour, which provides a comparison of the magnitude of the two facilities.

Finally, comparative emission factors (or objectives) for other Canadian authorities are not available for the Panel's reference. Ontario, the major location of steel production in Canada, has traditionally used a "point of impingement" approach (Ontario Ministry of Environment Regulation 308). However, as identified in correspondence submitted by the proponent (file 543-Pro.92), the point of impingement approach is being replaced by Ambient Air Quality Control (AAQC) values and emission guidelines. Similarly, the federal government, through the Canadian Environmental Protection Act (CEPA), recommends ambient air objectives, but not emission standards. A combination of emission standards and ambient air quality control appears preferable.

* * *

APPENDIX I

NOx, SOx AND PARTICULATE DEPOSITION: BACKGROUND

Overview

Air borne solids are deposited over a wide area of land, fresh water and saltwater by climatically determined dispersion of the stack plume. At any given time, the area impacted will depend on meteorological conditions and the temperature and velocity of the plume (for intermittent production facilities like Sherwood).

For particulate emissions, the efficient (arguably BACT) baghouses ensure that the solids from the Sherwood stack will always be of small particle size. According to the Seventh Supplemental Submission (page 25), 58% will be less than one micron in diameter. Such material has many more particles per gram, and much higher surface area per gram than untreated or fugitive emissions.

If particulate reaches the surface directly, it is considered to be dry deposition. Wet deposition can occur through entrainment of particles in rain, aerosols, fog or other precipitation that then contacts the surface. By these two types of deposition, solids are continually introduced at the surface of soil, and into the active surface films of water bodies. As such it is a continuous input to the natural equilibrium of these environmental compartments.

Once deposited, the particles will settle or migrate through each impacted zone. In fresh and saltwater deposition, such settling will be slower for small particles, especially if diffusion by gravity dominates other water circulation processes. Long residency times in the water column allows physical and chemical processes to occur, namely: (1) dissolution, (2) biological uptake, and/or (3) oxidation of CrIII to CrVI by hydrogen peroxide and other oxidants. Notably the material has much greater chance for uptake than when below the active surface of the sediment. The surficial layer of the sediment, in equilibrium with the adjacent water, and containing the greatest amount of organic material and biota, is also considered a critical location for contaminants.

It is important to note that the proponent considers all the deposited material to be contributed to the water compartment, rather than the sediment, on a yearly basis. This approach is taken to achieve an upper limit for impact, but it also allows for the greater availability of the material in the water during the settling process.*

Acidic material is created by the air oxidation of NOx and SOx to form acids (or acid salts) -- i.e. sulphur and nitrogen oxyacids such as sulphuric and nitric. Association of these species with

particulate can result in dry acid deposition. Wet deposition can then occur via entrained particles, or by the acid material actually dissolving in rain or other atmospheric water.

.....

* It is assumed that the metals and chemicals currently in equilibrium in the water, sediment or soil have the same rate of entry into various compartments (biota, water, sediment), and the same physical, chemical and biological activity as the deposition. Only comparative uptake and partitioning studies in baseline systems, and of the deposited material actually confirm this hypothesis. It has to be remembered that this uncertainty has been revealed throughout the Environmental Chromium literature --though usually as the failure to introduce chromium "naturally" in oxidation studies (i.e. manganese dioxide) or in toxicity studies (i.e. use of chromium III salts in fish LC_{50} experiments). It is deduced that any foreign or exobiotic chromium may be more or less bioavailable or more or less toxic than natural CrIII and CrVI forms until experimentally assessed. The somewhat undetermined nature of the solids emitted from the Sherwood facility is an important consideration of the Panel precisely because of the foregoing observations.]

* * *

APPENDIX J

DEPOSITION: AVAILABLE INFORMATION

The available data and information regarding deposition resulting from the Sherwood plant is not straightforward.

First, in the EIS, where the CRSTER model was used, the possibility of deposition being handled by the modelling was explicitly denied by the proponent:

> "Dry deposition fluxes of SO_2, NO_2, aerosols and suspended dust of the anticipated particle size range are considered to be small compared to uncertainties in the parameters required to specify the underlying dynamics (Hanna et al. 1982). Hence it was concluded that including these processes (eg. via the ISC model) would contribute little to the analysis of either air quality or fallout." (EIS, file 183-Pro.17, 4.26).
>
> "Gravitational sedimentation is unimportant for particles (less than) 5 um in diameter (Hanna et al. 1982)". (Ibid, p.4.73).

After discussion of the parameterization of other processes, the EIS concludes:

> "...the underlying dynamics are poorly understood, with the net situation being that order of magnitude approximations are the most that can be asked of any modelling exercise.
>
> In view of the questionable value of explicitly modelling the fallout of the characteristically small sized particulates, the approach adopted for this report was to evaluate the impact of particulate loading only in terms of air quality." (Ibid.).

In contrast, the EIS Addendum, using ISCST modelling, did provide wet and dry deposition rates (F_{dry} and F_{wet}) for chromium and sulphur dioxide (file 335-Pro.33,).

During the hearings, an F_{dry} value for chromium was given in units of $mg/m^2/yr$ (file 401-Pro.60) rather than units of $ug/m^2/yr$, as presented in the EIS Addendum (file 335-Pro.33).

Dry deposition rates for sulphate (grams/ha/yr) were different than the wet deposition units (kg/ha/yr) by the same factor of 1000. More confusing, as pointed out by Dr. R. Caton (file 347-Pan/Ex.20), was the estimate of "12.5 kg ha^{-1} y^{-1}" for "sulphur", as per page 5.25 of the EIS Addendum. It actually refers to SO_2, and expressed as sulphate would be "19 kg (SO_4) ha^{-1} y^{-1}", by Dr. Caton's calculations.

The background deposition rate (wet only) at Port Hardy is 12 kg (SO_4) ha^{-1} y^{-1} (B.C. Ministry of Environment, 1988, Acid Rain in British Columbia). In Dr. Caton's view, the potential maximum total, 31 kg ha^{-1} y^{-1}, was a matter of concern for this sensitive area.

Subsequently, at the hearings, the new total wet and dry value was given as 2.85 kg (SO_4) ha^{-1} y^{-1} (file 401-Pro.60). From this, certain questions arise:

(1) If F_{dry} is actually 1 kg ha^{-1} y^{-1}, should Total Depositional Flux be 3.85 kg ha^{-1} y^{-1} ?

(2) If 3.85 kg is the total, why does the reduction (from 19 to 3.85) not correspond to the reduction in projected SO_2 emissions?

eg: (a) EIS Addendum 917 kg SO_2/hour (fig. 5-2A)
(b) Seventh Supplemental 1.07 kg SO_2/hour (fig. 4-10)

The new value would be: (1.07/9.17) x 19 = 2.21 kg.

(3) The modelling is for a 60 meter stack. What are SO_4 values for other stack heights? (for example, 34 meters).

(4) What is the uncertainty in these values? If uncertainty is a factor of 10, as in the chromium loadings (Vd = 1 or Vd = 10), then concern may remain over SO_2 deposition. [The proponent does quote SO_2 values for Vd as 0.1 to 0.8 (EIS Addendum, p.5.25)].

Other submissions expressed concern over the level of SO_2 emissions. For example, the B.C. Ministry of Environment states:

> "The Ministry of Environment will consider the sensitivity of the local terrestrial and aquatic systems to acidic deposition, and consider the findings of the panel on the toxicity of chromium in the environment in determining acceptable levels." (file 359-Govt.37, p.11)

> "Due to the sensitivity of the north coast of Vancouver Island to acid rain damage, monitoring for acid precipitation and sulphate and chromium deposition in areas most likely to be impacted by plant emissions will be reviewed and expanded where warranted." (Ibid., p.11).

In the case of chromium, deposition is calculated by the proponent as 2.2 mg/kg dry weight (EIS Addendum), based on the upper (Vd = 10) value of 19 mg m^{-2} y^{-1}. The calculation though is for a 60 meter stack based on 44.2 grams/hour of chromium (total) emission from the stack (EIS Addendum, Table 4-10). The Seventh Supplemental

Submission states 29 grams/hour of total chromium, but requests the permitting limit be set at 50 grams/hour.

The Panel requested the following information from the proponent:

> "Deposition (Cr, SO_4, acid): Clarification of discussions on dry and wet deposition. Soil sensitivity testing should be improved to a greater level of reliability." (file 440-Panel.49, p.2).

It is regrettable that no clarification was forthcoming. This made it very difficult for the Panel to provide definitive comment on the environmental impact from total deposition on water and soil.

* * *

APPENDIX K

TOXICITY OF CHROMIUM TO AQUATIC ORGANISMS

In the EIS Addendum (p.5-29), the proponent reviews toxicity of chromium in the aquatic environment extensively, observing CrVI (in general) to be more toxic than CrIII. Acute toxicity values (96 hr LC_{50}) for CrVI range between 445 and 2000 ug L^{-1}. For CrIII, sensitive freshwater species had acute toxicity between 2000 and 3200 ug/L^{-1}, and marine species 3300 - 7500 ug L^{-1}. Significantly for fish, trivalent chromium in the dissolved ionic form is more acutely toxic (LC_{50} levels) than Chromium VI (22,000 ug L^{-1} compared to 100,700 ug L^{-1} for CrVI).

While these are high levels, the exposure of seaward migrating juvenile salmon to much lower levels may impair survival (230 ug L^{-1} CrIII in freshwater for four weeks). It is these latter chronic or sub-lethal concentrations that are of particular concern.

For example, Dr. Nriagu cited data from Netherlands researchers J.A. Janus and E. Krajnc (file 434-BI.46) for NOEC levels. NOEC, or No Observed Effect Concentrations, that were for CrVI in the range 35 - 260 ug L^{-1} for algae, 9 - 500 for crustaceans, and 100 - 3500 for fish. Notably, rainbow trout eggs and juveniles had values in the 30 - 200 ug L^{-1}, NOEC. For chromium III, NOEC values for algae were again 100 ug L^{-1}, for crustaceans (including the test species Daphnia Magna) values were 47 - 129 ug L^{-1}, and fish 19 - 200 ug L^{-1}.

It appears that some of these studies were done with chromium salts and are therefore subject to criticism. The known gill coating effects of freshly precipitated Chromium III has been pointed out by the proponent. However, the proponent also observes that "cold water salmonids are the most sensitive family of fish". (EIS Addendum, p.5-35).

In citing regulatory guidelines, the proponent notes that both B.C. Ministry of Environment and the Canadian Council of Resource and Environment Ministers set 20 ug L^{-1} for fish, 2 ug L^{-1} for the aquatic community (referred to by the proponent as zooplankton and phytoplankton). The United States EPA has set guidelines (refer to EIS Addendum, p. 5-38) concentrating on the survival of salmonid (known to be chromium sensitive species) and the protection of the aquatic invertebrate community. Interestingly, these levels (for example: 11 ug L^{-1} for 4 days average concentration of CrVI for freshwater organisms, and 50 ug L^{-1} for 4 days average concentration of CrVI for marine organisms) are given by oxidation state, and are <u>not</u> long term chronic exposure levels. No saltwater criteria for Chromium III has been derived.

* * *

APPENDIX L

DESCRIPTION OF "BACT" PROCESS

DRAFT

TABLE IV-1. - KEY STEPS IN THE "TOP-DOWN" BACT PROCESS

STEP 1: *IDENTIFY ALL CONTROL TECHNOLOGIES.*

- LIST is comprehensive (LAER included).

STEP 2: *ELIMINATE TECHNICALLY INFEASIBLE OPTIONS.*

- A demonstration of technical infeasibility should be clearly documented and should show, based on physical, chemical, and engineering principles, that technical difficulties would preclude the successful use of the control option on the emissions unit under review.

STEP 3: *RANK REMAINING CONTROL TECHNOLOGIES BY CONTROL EFFECTIVENESS.*

Should include:

- control effectiveness (percent pollutant removed);
- expected emission rate (tons per year);
- expected emission reduction (tons per year);
- energy impacts (BTU, kWh);
- environmental impacts (other media and the emissions of toxic and hazardous air emissions); and
- economic impacts (total cost effectiveness, incremental cost effeciveness).

STEP 4: *EVALUATE MOST EFFECTIVE CONTROLS AND DOCUMENT RESULTS.*

- Case-by-case consideration of energy, environmental, and economic impacts.
- If top option is not selected as BACT, evaluate next most effective control option.

STEP 5: *SELECT BACT*

- Most effective option not rejected is BACT.

Source: U.S. EPA. "'Top Down' Best Available Control Technology Guidance Document". draft document, Environmental Protection Agency, Washington, D.C. March 15, 1990.

APPENDIX M

SEDIMENT LOADING: BACKGROUND INFORMATION

Chromite Solubility

Contamination of marine sediments cannot be considered in isolation from the water column. Trace metals and organics are in a dynamic equilibrium that sees small amounts of material in the sediment continually dissolve and then re-enter the surface layer of the sediment and its biota by precipitation, ingestion, etc. Concentrations in the sediment water and in the water column may differ as well. Experts in the field define a parameter "Sediment-Water Equilibrium Partitioning", known as the "SWEP" approach. It is recognized that bulk chemical concentrations of trace metals in sediments are related to bioavailability by a complex set of physical and chemical factors.

For purposes of review, it is useful to consider these two compartments (water and sediment) together. Related fresh water and stream sediment data will often be compared. Here, the Panel returns to the question of the bioavailability of chromium in chromite ore.

At the hearings, the Panel's consultant, Dr. E. Peters, an eminent metallurgist and expert on high temperature process thermodynamics (including chromium), made observations on the absolute insolubility and inertness of chromite in seawater. This is quoted from the Transcripts by the proponent's counsel in his final submission: file 559-Pro.95, p.23-24). In contradiction, Dr. Jerome Nriagu, Environment Canada, was more qualified in his judgement. He suggested material of small particle size could be dissolved or made bioavailable, through the sequence of oxidation of Chromium III to Chromium VI, followed by reduction back to Chromium III. The Chromium III thus formed is dispersed, open to complexation and hence more available.

At this point, it is important to note the controversy over the chromite ore leaching tests. As reported in the EIS, section 4.3 (p.22), leaching tests of raw materials (coal, silica and chromites) were conducted with seawater and with simulated rainwater (pH 5.8, rising to 7.5 during the test). High levels of removal of Chromium III were found for Indonesian concentrate, in the amount of 0.140 mg Litre^{-1}. A Canadian concentrate gave 0.0006 mg L^{-1}. (The permissable Special Waste leachability for Chromium is 0.1 mg L^{-1}). The high Indonesian levels persisted on re-testing. Notably, systematic sub-sampling protocols were not used on the drums of chromite as received.

The SWEP procedure requires 0.5 N. acetic acid as leaching solution. It was abandoned on the basis of the potential for acetic acid reducing Chromium VI in the leachate. However, the margin of

safety for heavy metals (cadmium, copper, lead) intended by using an acidic leaching solution (SWEP procedure) was then lost in the procedure used. Clearly standard SWEP tests must be done on the chromite ore (and, by inference, on the slag to be stockpiled).

It has been argued that the 0.14 L^{-1} of Chromium III represented "colloidal" material. A very fine 0.45 um filter is used on the leachate before analysis. The Panel notes that is just such fine material that concerns Dr. Nriagu. He suggest it may, even if a solid, be potentially bioavailable or subject to solubilization.

Background Information on Sediment Quality

The current policies of Environment Canada, the B.C. Ministry of Environment and other agencies (United States in particular) regarding chromium levels in sediment were provided to the Panel by Dr. D. Goyette, both at the public hearings (file 482-BI.58) and in a further submission (file 531-Govt.58).

All of the recommended standards and the data used to indicate contamination and pollution levels for chromium and other heavy metals are based on total elemental concentration. There is no distinction by source (i.e. chromite for Chromium III), by oxidation state (eg. Chromium III or Chromium VI) or other speciation (i.e. complexation). The sources provided clearly state that the uncertainty in mobility, toxicity and bioavailability of metals in their different forms makes it necessary to take this approach.

The documents surveyed by Dr. Goyette and their main impact on the Chromium question, are as follows:

(1) The National Oceanic and Atmospheric Administration NOAA, Technical Memorandum NOSOMA52 March 1990 1-60, Appendices.

"The Potential for Biological Effects of Sediment Sorbed Contaminants Tested in the National Status and Trends Program".

In reviewing NOAA, Dr. Goyette notes (file 531-Govt.58, p.4):

"a) there are no single chemical spiked bioassay data available for Cr (so called SSB values)
b) there are no screening level concentration approach or sediment-water equilibrium partitioning approach data available for Cr.
c) no overall effects threshold is apparent form available data on Cr."

Next, from a large data base, NOAA provides "ER-L" (Effects Range - Low) and "ER-M" (Effects Range - Medium) values for Chromium. The

confidence in these values is considered to be moderate. These are as follows:

ER-L 80 ppm (80 ug/g. sediment)

ER-L represents the concentration above which adverse effects may begin or are predicted among sensitive species and/or life stages.

ER-M 145 ppm (145 ug/g. sediment)

ER-M is the concentration above which effects were frequently or always observed or predicted among most species.

Apparent Effects Threshold (AET) is the level where biological effects occur 100% of the time with a 95% confidence level. While overall AET levels have not been established, some data are available:

Puget Sound:	amphipod bioassay	270 ppm.
	benthic community structure	260 ppm.
San Francisco Bay:		
	bivalve larvae	280 ppm.
	amphipod bioassay	370 ppm.

(2) Washington State Department of Ecology, September 1990: Final Draft, Sediment Management Standards, Chapter 173-204, WAC, 105 pp.)

This draft document sets sediment quality standards, sediment source control standards and sediment clean-up standards. The quality standards for contaminants of interest are in Table 1. These may appear to be close to AET values. However they are maximum tolerable levels, as indicated by the column "Clean-up Screening Levels" (for Puget Sound Marine Sediment). The latter term is defined as "establishing the levels above which station clusters of potential concern are defined as clean-up sites". (Ibid., p. 68).

(3) Coquitlam-Pitt River Area, Burrard Inlet Water Quality Assessment and Objectives, July 18, 1990.

"Provisional water quality objectives are set to protect aquatic life, wildlife and primary-contact recreation in Burrard Inlet, Lynn Creek and School House Brook".

Notably, chromium, again defined as total chromium, is set at 60 ug/g. (60 ppm.) For associated water quality, False Creek, a highly contaminated zone is set at 50 ug/Litre maximum, while

tributaries to Burrard Inlet are set at 2 ug/L., or 0.0002 mg/L. This latter value can be compared with the Canadian drinking water guideline (CCREM, Canadian Council of Resource and Environment Ministers) of 0.050 mg/L, and the guidelines for fish of 0.02 mg/L.

In regard to the 60 ppm. sediment value, it should be noted that other jurisdictions take a stringent approach to standards. For illustration, Goyette cites the Great Lakes Harbour scale:

non-polluted	under 25 ppm.
moderately polluted	25 to 75 ppm.
heavily polluted	over 75 ppm.

Currently, Hardy Bay values (as measured at eight stations in May 1990 by Environment Canada) are 21.7 to 43 ppm. Other non-polluted (i.e. base line) surface sediment values in British Columbia were 21-40 ppm. (Seymour/Belize, Loughborough Inlet, Sunderland Channel; Environment Canada, 1986-89). These unpublished data are cited by Goyette in File 531.

* * *

APPENDIX N

QUAKEOLTH TREATY

(also known as the Fort Rupert Treaty)

This one of a series of treaties between native bands of Vancouv
Island and the Hudson's Bay Company, representing the Briti
crown, which were signed in the mid-1800's. These are frequent
referred to generically as a group as the "Douglas Treaty".

QUEACHAR TRIBE—FORT RUPERT.

KNOW all men, we, the chiefs and people of the Tribe called Queachars, who have signed our names and made our marks to this deed on the eighth day of February, one thousand eight hundred and fifty-one, do consent to surrender, entirely and for ever, to James Douglas, the agent of the Hudson's Bay Company on Vancouver Island, that is to say, for the Governor, Deputy Governor, and Committee of the same, the whole of the lands situate and lying between McNeill's Harbour and Hardy Bay, inclusive of these ports, and extending two miles into the interior of the Island.

The condition of or understanding of this sale is this, that our village sites and enclosed fields are to be kept for our own use, for the use of our children, and for those who may follow after us; and the land shall be properly surveyed hereafter. It is understood, however, that the land itself, with these small exceptions, becomes the entire property of the white people for ever; it is also understood that we are at liberty to hunt over the unoccupied lands, and to carry on our fisheries as formerly.

We have received, as payment, Sixty-four pounds sterling.

In token whereof, we have signed our names and made our marks, at Fort Rupert, Beaver Harbour, on the eighth day of February, one thousand eight hundred and fifty-one.

(Signed) WALE his x mark.
and 11 others.

Witnesses,
(Signed) WILLIAM HENRY MCNEILL, C. T., H. B. Co.
CHARLES DODD, Master, Steamer Beaver.
GEORGE BLENKINSOP, Clerk, H. B. Co.

QUAKEOLTH TRIBE—FORT RUPERT.

KNOW all men, we, the chiefs and people of the Tribe called Quakeolths, who have signed our names and made our marks to this deed on the eighth day of February, one thousand eight hundred and fifty-one, do consent to surrender, entirely and for ever, to James Douglas, the agent of the Hudson's Bay Company on Vancouver Island, that is to say, for the Governor, Deputy Governor, and Committee of the same, the whole of the lands situate and lying between McNeill's Harbour and Hardy Bay, inclusive of these ports, and extending two miles into the interior of the Island.

The condition of or understanding of this sale is this, that our village sites and enclosed fields are to be kept for our own use, for the use of our children, and for those who may follow after us; and the land shall be properly surveyed hereafter. It is understood, however, that the land itself, with these small exceptions, becomes the entire property of the white people for ever; it is also understood that we are at liberty to hunt over the unoccupied lands, and to carry on our fisheries as formerly.

We have received, as payment, Eighty-six pounds sterling.

In token whereof, we have signed our names and made our marks, at Fort Rupert, Beaver Harbour, on the eight day of February, one thousand eight hundred and fifty-one.

(Signed) WAWATTIE his x mark
and 15 others.

Witnesses,
(Signed) WILLIAM HENRY MCNEILL, C. T., H. B. Co.
CHARLES DODD, Master, Steamer Beaver.
GEORGE BLENKINSOP, Clerk, H. B. Co.

SAALEQUUN TRIBE—NANAIMO.

A similar conveyance of country extending from Commercial Inlet, 12 miles up the Nanaimo River, made by the Saalequun Tribe, and signed Equoniston and others.

APPENDIX O

GLOSSARY OF TERMS

This short glossary contains the many of the technical words and abbreviations of this report which are not necessarily in common usage. The purpose of this glossary is to assist readers with comrehension of the text, rather than to provide complete definitions or descriptions.

Alumina:	Aluminum oxide, expressed as Al_2O_3.
AOD:	Argon - Oxygen - Decarburization: method used in steelmakingt to lower the carbon content of the moten metal.
BACT:	Best Available Control Technology.
Benthic:	Oceanographic term to describe forms of life inhabiting the seabed.
Bioavailable:	Capability of substances to be absorbed by living organisms, either plant or animal, into their tissues.
CO:	Carbon monoxide.
CO_2:	Carbon dioxide.
CEPA:	Canadian Environmental Protection Act.
Chromite:	Mineral; oxide of iron and chromium.
Complexation:	The binding of metal ions by organic compounds, mainly organic acids.
CRSTER model:	Air dispersion model for single sources; from the United States EPA.
Daphnia magna:	Small invertebrate species used for Toxicity testing.
Diabase:	Medium to coarse grained igneous rock.
Diopside:	Mineral; calcium-magnesium silicate.
Dolomite:	Mineral; calcium-magnesium carbonate

EIS:	Environment Impact Statement.
Ferrochromium:	Iron-chromium metal alloy.
GEP:	Good Engineering Practice (as defined by the U.S. Environmental Protection Agency).
H_2S:	Hydrogen sulphide, a highly toxic gas of noxious odour.
ISCST:	Air dispersion model for industrial sources; from the U.S. EPA.
LAER:	Lowest Achievable Emission Rate; applied to hazardous pollutants.
LC:	Lethal content; notation for the lethal level of a given substance.
LOAEL:	Lowest Observable Adverse Effects Level.

Metric Units:

mL:	Millilitre; one thousandths part of a litre.
L:	Litre; or 1000 mL.
m^3:	Cubic meter (metre).
Nm^3:	Normal cubic meter; a cubic meter at 20°C and 1 atmosphere of pressure in British Columbia convention.
um:	Micrometre; or one millionth part of a litre.
g:	Gram.
kg:	Kilogram; 1000 grams.
tonne (t):	1000 kilograms
mg:	Milligram; one thousandths part of a gram.
ug:	Microgram; one thousandths part of a milligram; one millionth part of a gram.
ng:	Nanogram; one thousanths part of a microgram; one millionth part of a milligram.

NOAEL:	No Observed Adverse Effects Level; a term used by the U.S. EPA.
NOx:	General expression for variety of nitrogen oxides emitted during combustion of fossil fuel in the presence of nitrogen.
NOEC:	No Observed Effects Concentrations.
Organo Sulphur Volatolization:	The release of suphur containing compounds in a gas.
PAH:	Polynuclear aromatic hydrocarbons; expression for variety of hydrocarbons which are produced by combustion.
pH:	Expression of acidity/alkalinity level; numbers greater than 7 indicate acidity, and numbers less than 7 indicate alkalinity (the opposite of acidity).
Photic zone:	The upper level of water bodies (particularly the sea) where sufficient sunlight penetrates to allow sunlight-dependent organisms to exist.
QA/QC:	Quality Assurance and Quality Control.
Redox Cycle:	The sequence of oxidation of metal or other species, followed by reduction back to the original state.
Rfc:	Reference Concentration for Chronic Inhalation Exposure; a term used by the U.S. EPA.
RTDM:	Rough Terrain Diffusion Model; a air disperson model.
Silica:	Silicon dioxide; or sand.
Silicon:	Metallic element (Si).
Smelting:	Extraction of metal from ore with melting and a reducing agent such as carbon.
Solubilization:	The process of dissolving in a liquid.
SOx:	General formula for variety of sulphur oxides emitted during combustion of sulphur-containing fossel fuels.

Speciation:	The chemical forms that an element can take; usually applied to natural systems.
STP:	Standard temperature and pressure; 0°C and 1 atmosphere of pressure.
SWEP:	Special Waste Extraction Procedure; refer to Section 3.4.5
SWEP:	Sediment-Water Equilibrium Partitioning (see Appendix M).
TDS:	Total Dissolved Solids
TLV:	Threshold Level Values.
TRS:	Total Reduced Sulphur.
TSS:	Total Suspended Solids.
U.S. EPA	United States Environmental Protection Agency; lead agency for establishing environmental protection standards and for monitoring and regulating the output of toxic substances into the environment.
VOD:	Vacuum - Argon - Decarburization; method used in steel making to lower the carbon content of the molten metal.
VOAD:	Vacuum - Argon - Oxygen - Decarburization; see VOD above.
WEDC:	Western Economic Diversification Canada; agency of the federal government of Canada.